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MONDAY, MARCH 8, 1976

The hearing reconvened at 9:10 A.M. on Monday, March 8, 1976, in the Chambers of the Montana House of Representatives, State Capitol, Helena, Montana.

The Honorable Carl M. Davis, Hearings Examiner, presided over the proceedings.

APPEARANCES:

Applicants:

William M. Bellingham, Esq.
John L. Peterson, Esq.

Department of Natural Resources and Conservation:

Arden E. Shenker, Esq.
Donald MacIntyre, Esq.
Ted J. Doney, Esq.

The following proceedings were had:

HEARINGS EXAMINER: Are counsel ready to proceed this morning?

MR. SHENKER: Yes, sir, the Department of Natural Resources is ready.

MR. PETERSON: The Applicants are ready.

HEARINGS EXAMINER: Very well, I understand the next witness will be called by the Department of Natural Resources.

MR. SHENKER: Thank you, sir. As our next witness, we will call Dr. Douglas Ira Hammer.

DR. DOUGLAS IRA HAMMER, called as a witness by the Department of Natural Resources and Conservation, having been first duly sworn upon his oath, both as to his written direct testimony and as to the oral testimony to follow, was examined and testified as follows:

MR. SHENKER: There were three typographical errors that I should correct in Dr. Hammer's statement. We do offer the statement of testimony of Dr. Hammer at this time as evidence on behalf of the Department of Natural Resources and Conservation. Page 1 of his statement, line 6, the reference to the university should be Tufts University instead of Tulsa University. The same mistake occurs on pages 12 and 13. The word "health" is misspelled twice in two different ways. The word, health, appears on line 28, page 12, as "help." and it should be "health," and on page 13, line 19, it appears as "health," misspelled, and should be correctly spelled. Through and with the testimony of Dr. Hammer at this time, we also offer DNR Exhibit No. 160 for illustrative purposes. That exhibit is referred to in the statement of Dr. Hammer at pages 4, 5 and 7, and on pages 4, 5 and 7, where the exhibit is referred to, the number of the exhibit, 160, should be inserted in the text of the statement.

HEARINGS EXAMINER: Very well, thank you, sir.

(THE WRITTEN DIRECT TESTIMONY OF DR. DOUGLAS IRA HAMMER WAS DIRECTED TO BE INSERTED AT THIS POINT.)

STATEMENT OF TESTIMONY
OF
DR. DOUGLAS IRA HAMMER

My name is Douglas Ira Hammer, I am a physician and an epidemiologist. I received my doctorate in medicine in 1962 from ~~Tulsa~~ Tufts University. I had residency training in infectious disease, pediatrics and general preventive medicine at the infectious disease laboratory of the Department of Pediatrics of the University of Southern California, as well as the Department of Epidemiology at the Harvard School of Public Health in Boston, Massachusetts. I am a Diplomat of the American Board of Preventive Medicine, and a Fellow of the American College of Preventive Medicine. I am a member of the American College of Emergency Physicians. I hold both a masters degree of Public Health and a doctor of Public health from Harvard University School of Public Health in Boston, Massachusetts. My doctorate in Epidemiology will be awarded this year. My thesis is entitled "Acute Lower Respiratory Disease in Children in Relation to Ambient Sulfur Oxides and Total Suspended Particulate Exposure." I am licensed to practice medicine in several states. I hold several clinical and academic appointments, including appointments at the University of North Carolina, Duke University and the University of Cincinnati. I also am an affiliate faculty in Emergency Cardiac Care for the American Heart Association.

On July 1, 1963, through August 31, 1975, I was an officer on active duty in the United States Public Health Service. Upon leaving the Public Health Service, I held a Director grade, which is equivalent to a full colonel in the United States Army.

During the time I was in the Public Health Service, I worked for the Division of Air Pollution, which subsequently became among other things, The National Air Pollution Control Administration, and most recently was incorporated into the United States Environmental Protection Agency. I have had extensive experience both in the field and in the theory of environmental pollution and environmental health. My appointments, starting in 1971 with the Environmental Protection Agency, include Acting Chief of Epidemiology Branch, Special Assistant for Health Effects, Senior Medical Research Epidemiologist and finally, Scientific Advisor for the Human Studies Laboratory at the National Environmental Research Center, the United States Environmental Protection Agency, Research Triangle Park, North Carolina, as of August 1975 when I left to go into full-time Emergency Medicine.

I have worked in the field of air pollution and environmental pollution for approximately 12-1/2 years and have published over 35 papers in the field of infectious diseases in environmental pollution. I belong to several professional and scientific organizations. I currently reside at 114 Anchor Way, New Bern, North Carolina, 28560, and I am in the full-time practice of Emergency Medicine at Craven County Hospital in New Bern, North Carolina, as well as Rex Hospital in Raleigh, North Carolina, where I am the Director of the Emergency Department.

I take time today, and subsequently at the hearing and cross-examination from a busy practice of emergency medicine and the teaching of emergency care, to testify with regard to deleterious effects of the exposure of the general population to ambient sulfur oxides and total suspended particulate matter.

I will gladly supply a copy of my curriculum vitae, as well as the references to any documents that I refer to in my testimony.

I will first discuss the deleterious health effects of exposure to ambient sulfur oxides and particulate matter of the general population. In doing so, I will discuss the concept of public health and who is at risk to environmental exposure; the concept of biological response to pollutants or noxious stimuli; the general results of sulfur oxide and particulate air pollution exposure that are well-known health effects; the uncertainties with regard to sulfur oxide and particulate air pollution health effects--that is, the areas which have not yet been well studied; and in conclusion, to summarize my statement.

Just as it costs money to control air pollution, the effects of air pollution, namely the health effects, also have costs which are borne by our society--costs which are difficult to calculate but nevertheless large.

What is the public health, who is at risk and who must one protect? This is an easy question to answer. The public health includes everybody in the entire population of a given area or location. Therefore, it subsumes occupational health and it includes not only healthy working men and women, but also the young, the aged, and those people who are sick either on a temporary basis or a chronic basis. It includes people that suffer temporary physiologic stresses such as pregnancy or exercise. It includes people with varied genetic backgrounds, who within the same environment may suffer differently. Therefore, different philosophies must prevail when one thinks about the public health rather than occupational health with regard to protection. People who work in occupations make their living from the occupation and therefore take a little more risk since there is some economic gain, than people walking around in the ambient environment who do not bear such relationship to the general environment. In my mind public health, although encompassing certain personal habits such as over-eating or cigarette smoking which have been linked to excess morbidity and mortality, is nevertheless different since some of these things are amenable to control and some are not amenable to control. Because you can't control all of the diseases is no justification to assume you shouldn't control any of them. In other words, just because you can't get people to stop over-eating doesn't necessarily mean that you shouldn't worry about trying to get them to stop smoking. In a similar vein, air pollution which effects smokers and non-smokers and obese and non-obese people is amenable to control and does bear an excess morbidity and mortality risk. Therefore, air pollution should be controlled even though one cannot control all of the diseases in the world. To paraphrase a line from Dietrich Bonnhofer,"...one's task is not to turn the world upside down, but to do things with due consideration of reality."

Human responses to noxious environmental stimuli will vary both with the dose of the specific pollutant as well as within the individual. Therefore, it is quite useful to think in terms of a biological response spectrum. Exhibit 16-C, for illustrative purposes which I prepared, shows a biological response model for pollution exposure in the form of a pyramid. The base of the pyramid, or on the horizontal scale, represents a proportion of the population affected, whereas the vertical scale represents increasingly severe responses to noxious stimuli. It can be seen from the figure, that as of course for any given level of exposure, when you go up the scale less people are affected, but the effects are more severe. We hear a great deal about the concept of variability in biology, and this is true. Things vary; people vary. I would like to point out that because something varies doesn't mean that you cant study it or characterize it. On the contrary, some of the most challenging and intellectually stimulating parts of research ~~is~~ are deciding how to go about starting something which is quite variable.

The first point from Exhibit 16C, is that as you increase environmental exposures to noxious stimuli, one sees more severe biological responses on the average. The second point, is that for any given level of exposure, one may see any or all of this response spectrum because of the tremendous variability and sensitivity in the general population that I mentioned previously. To specifically discuss the levels in the pyramid, one begins at the top with mortality or death; second, morbidity or clinical sickness. These, of course, represent the extreme responses to pollutant exposure. There have been several reports from several countries relating short term high pollution exposures to excess dust and excess sickness. I think it goes without saying, but I will underscore it, that to think of setting any kind of protection for the public health purely on mortality or even morbidity would be extremely cruel and shortsighted. When one thinks of the history of public health and thinks of the episodes which were linked to severe morbidity and mortality, one is not led to think of humane and reasonable environmental standards, but rather public health disasters. I would like to point out that I realize that the vertical scale of this figure of five categories are arbitrary categories. If you think about it, even mortality or death only becomes finite after a long enough period of time. I think the recent cases regarding brain death versus biological or clinical death have borne this out.

Likewise for morbidity or illness, one must think of illness in many dimensions. There are people who feel fine, but may have an undiscovered cancer which will kill them. On the other hand, there are people who sometimes may feel deathly ill for a few minutes and recover. So the fact that you feel good or bad, doesn't always mean that you are healthy or not healthy. It is merely one dimension of illness. The second point about morbidity is that there are many illnesses which occur in the population which never get tabulated at a hospital or a doctor's office. So these two places don't always give us complete records in the community, although they are certainly good for specific types of illness. For example, if you had a broken leg, I feel that we would ascertain most broken legs in the country by checking hospital records. But, if one were interested in acute respiratory illnesses or even chronic respiratory illnesses, one expects to miss many of these illnesses by restricting studies to state records, hospital records, or even records in doctor's offices. Physiologic sentinels of disease refer~~s~~ to physiologic changes which are pathological. That is, changes which do not necessarily mean that you are sick, but if you keep them up, it means they will lead to illness. Examples of this phenomena are elevated blood lead levels which are not high enough to cause clinical illness, but nevertheless are regarded as unhealthy; changes in blood sugar which would indicate subclinical diabetes again in a person who doesn't feel too bad, but if this condition persists, would eventually have a decreased morbidity and mortality; and lastly, changes in blood pressure which again are minimally elevated and therefore people may not feel sick, but they as a group also have a decreased morbidity and mortality when compared to people without elevated blood pressure in the general population.

Physiologic changes of uncertain significance, in my mind, represent measurable changes, the meaning of which are not entirely clear at this time. They may, as we get more understanding of them, wind up being classified upwards into physiologic sentinels of disease; on the other hand, they may just be things which one can measure and may bear no relation to outcomes of morbidity and mortality.

You will note Exhibit 160, prepared by me for illustrative purposes, has a dotted line between physiologic sentinels of disease and physiologic changes of uncertain significance, since from physiologic sentinels of disease up is general where adverse health effects are defined for legal purposes and are generally accepted for legal purposes and that physiologic changes of uncertain significance and pollutant burdens as well, are generally not considered health effects, although some people do so. These are areas where there is much greater argument.

Levels of pollutants in the body where environmental materials such as heavy metals, organic materials which may deposit in the areas such as bone, hair, fat tissue and certainly indicate exposure but do not necessarily indicate harmful effects. Thus when a physician or epidemiologist, or any concerned person thinks about human health effects, either in general or as a response to specific environmental pollutants, it is important to think of them in terms of a broad biological response. Failure to do so can impose severe health costs upon the community.

The concept of the response spectrum also explains in part why two supposedly equally trained scientists appear to disagree about the health effects of a given pollutant. They might be looking at the same set of data and one sees physiologic changes of uncertain significance or even physiologic sentinels of disease, and says well I don't really think that's harmful because that's not killing anybody, where someone else says, well you're not killing anybody, but you have all these changes which are not healthy and may lead to sickness and death. Thus you may have two equally competent scientists giving you opinions on different facets of the same truth. Hopefully, this concept of biological response will give you a key to understand why people may differ in what they call a health effect, or at least the seriousness of health effects of exposure to a certain pollutant.

The National Air Pollution Control Administration published air quality criteria for sulfur oxides and air quality criteria for particulate matter in 1969. These documents summarized known information with regard to health effects of sulfur oxide and particulate matter that was known at that time. They are particularly useful because, in the health chapters in each volume, they review critically and discuss the strength and weaknesses of the major studies that are cited. In the epidemiological appraisals in both volumes, health effects discussed are related insofar as possible to specific pollutant concentrations over specific time intervals. I also should emphasize that the lower values would by no means imply a "no effect" level of the pollutants. Since that time, the Federal Standards and the information underlying have been reviewed by a Senate committee--a committee made up of scientists at the request of the Office of Management and Budget--and by a panel of scientists of the National Academy of Sciences. They have all agreed that the original data and forthcoming data were reasonable and that the new information in no way contradicted the old information. That is to say, the initial Federal Standards that were set, as well as the idea that health effects occurred at reasonably low ambient levels, was correct; and, secondly, the more recent information has suggested that the original standards had even less of a margin of safety than thought at the time they were adopted.

Studies on sulfur oxides and particulate matter have been done in the United States, Russia, Great Britain, Italy, The Netherlands, Japan and Australia. Studies in the United States were done both in urban and rural areas. And what few studies are available suggest that if you do control pollution one finds health benefits. That is, excess morbidity seems to disappear or decrease. These studies completed in several different countries by different investigators came up with basically the same set of conclusions, which strengthen rather than weaken that conclusion.

In some of the earlier studies as well as some of the more recent studies it was very difficult to separate sulfur oxides from particulate matter in terms of environmental exposure. This should not bother a public health person, since sulfur oxides and particulate matter are parts of fossil fuel combustion, and are often found in the same environment. Sulfur dioxide gas is sometimes said to be relatively harmless. Firstly, the term relative means different things to different people, as I discussed before, for example, with regard to the biological response spectrum. Secondly, sulfur dioxide gas as a pure gas rarely occurs in the ambient environment for longer than a few seconds. It is invariably mixed with other particles. It is invariably converted to acid sulfate aerosols and many other compounds, all of which are considerably more toxic than sulfur dioxide gas per se.

Particulate matter does not represent a single entity, but rather a heterogeneous group of particles in the air, and of course the thing that determines the toxicity of these particles is a function of both the particle size and their chemistry. So, although measured SO_2 or predicted SO_2 and total suspended particulate levels may only be indices of all the chemical compounds in the air, they are nevertheless very useful indices for the epidemiologist. A good example for analogy for this is cigarette smoking. Pack years, in other words the number of years that you smoke so many packs of cigarettes, correlates very well with lung cancer and also the risk of chronic respiratory disease. However, a moments thought tells us that pack years never tells you exactly what in the cigarettes is causing the lung cancer and chronic respiratory disease that you are seeing. It is also true that if you stop smoking, you decrease the risk of lung cancer and of chronic respiratory disease very quickly, even though you may never have known what was in the cigarette that caused it; and likewise, although there is not anywhere near as much information, what information is available suggests that if you decrease SO_2 and particulate matter in the ambient air, you avoid the health effects that they may cause at higher levels.

What kinds of health effects have been associated with exposure of sulfur oxide and suspended particulate matter? There are really two kinds of health effects. One simple way to think in terms of health effects, is health effects to short term exposures to pollutants and health effects related to long term exposures to air pollutants. As I mentioned previously, the health effects that I am about to mention as far as I know, have affected smokers as well as non-smokers, obese as well as non-obese people, and all social classes. As a matter of fact with data from the Environmental Protection Agency accumulated in the past few years, the first good sets of data of studies of non-white as well as white children, or specifically black children, suggests--and this is not surprising if one thinks that air pollution does cause acute lower respiratory disease or at least excess acute lower respiratory disease in children--that both black and white children were equally affected. Therefore, I believe it is safe to say that air pollution acts without regard, certainly, to race, sex or social class.

In terms of the health effects that are generally associated with increased short term exposures to sulfur dioxide, include mortality, aggravations of symptoms in persons with pre-existing heart or lung disease (usually people with heart disease or chronic respiratory disease), aggravation of symptoms of people who have asthma, and acute irritation symptoms in the general population such as cough, chest discomfort, throat discomfort, headache and eye discomfort. In terms of the effects to be associated with long term exposure, again there are effects associated with mortality, increased chronic respiratory disease symptoms in adults, increased acute lower respiratory disease frequency in children (those both with and without a history of asthma), increased respiratory disease in families, both in parents and their children, and alterations in pulmonary functions--that is pulmonary or lung functions.

Of particular concern is acute lower respiratory disease in children because there is increasing evidence indicating that children who suffer repeated respiratory infections in childhood from no matter what cause, do in fact have an increased risk of chronic respiratory disease as adults. Therefore, anything which contributes to excess acute lower respiratory disease in children such as air pollution, would tend to increase this risk of chronic respiratory disease as an adult. The kids really pay for it twice...once when they are kids and perhaps long years after they grow up. By these facts a hypothesis may not have the same press appeal that a few cases of vaginal cancer linked to diethyl stilbestrol in mothers or really severe illness linked to ketone exposure have. And of course, we understand this. But, there are a heck of a lot more children that are affected.

I would like to say something briefly about the public health cost to the community of air pollution. I agree that what the economists have called damage functions are very difficult to calculate for ~~help~~ health, not only for environmental pollution, but in terms of most things. The other side of this, and I feel very strongly about it because I am a public health physician, is that just because it is difficult to calculate something doesn't mean that there is no cost associated with it. Respiratory illnesses are the commonest illnesses that man experiences. In terms of children anywhere from 50 to 85% of all the illnesses that children ever have are respiratory illnesses, so that they are frequent illnesses and even a small increase will get to be a lot of cost in terms of medicine, in terms of work interruptions and terms of aggravations. This is true not only for children, but for grown-ups with their acute respiratory illnesses as well. If it is true that repeated acute lower respiratory infections in childhood increase the risk of chronic respiratory diseases in adulthood, which I believe it is, then how does one even begin to calculate a damage function for this? Yet, who among us would say that there is no cost, both economic and social, associated with such a hazard.

There are still areas of uncertainty with regard to sulfur oxide and particulate matter exposure and their ~~helth~~ health effects. There are areas where we still have little or no information, yet they may be of serious concern. For example, the relationship of sulfur oxides ~~in~~ and particulate matter to cancer, to genetic effects, to other long term effects which have not either had ample time for exposure or we do not yet possess the tools to study. Possible interactions of particulate matter with other gases or particulate matter with metals or organic materials and things like ozone and sulfur oxide need to be studied. The original federal criteria document in 1969 described synergistic interactions between exposure to ozone and sulfur dioxide. That is, if you are exposed to one part of SO_2 you may get an effect of one; if you are exposed to one part of ozone you may get an effect of one;, but, if you are exposed to one part of ozone and one part of SO_2 you may get an effect of three. That is, the synergisim means you get a stronger effect from combining exposures than you would expect from the arithmetic equivalent of each one Synergisism has been known for many years. In the past few years, studies of pulmonary function have shown that sulfur dioxide and ozone acts synergistically, or may very well act synergistically, on human lung function. So while it is possible that some interactions of pollutants may be antagonistic--in other words that they really may protect against one another and sometimes one does see this in at least experimentally different heavy metal poisonings--it is more than likely that there will either be additive effects or synergistic effects. Even the fact that we know if we put pure SO_2 and pure simple particulate matter in the air, that very rapidly we see a whole chemical series of acid sulfate aerosols and that these sulfur oxide compounds, where bound to particles, produce again suspended sulfates which may represent another general statement for a whole class of toxic materials. So by using indices such as measured sulfur dioxide or particulate matter for exposure, if anything we are probably underestimating the true effects that are going on at those levels of exposures.

In summary, it is eminently clear that exposure to ambient sulfur oxide and total suspended particulate matter is associated with adverse health effects. These effects are a function of both the duration and the concentration of the pollutants involved. Health effects related to both short term exposure and long term exposure to these pollutants span the response spectrum from physiologic changes of uncertain significance through physiologic changes which are precursors of disease through morbidity or sickness through mortality or death. Hence, before one does anything which would add measurable amounts of sulfur oxide and particulate pollution to the atmosphere and to the environment, one must consider this very carefully. This is particularly difficult in the modern society. For example, in the old days when the classical epidemics were plague and smallpox and they wrought havoc with the community, everybody pretty much agreed that plague and smallpox were not good things, except perhaps plague bacilli among themselves and the smallpox viruses among themselves. Today, the things which cause pollution, the things which cause disease, the things which aggravate our environment are part and parcel of the society in which we live and the comforts which we use. So it is much more difficult to make decisions about what to do. Colstrip is one of those difficult decisions, because at the moment nobody positively knows for sure just what the health effects of two units will be upon the town people, let alone what four units will do to them.

HEARINGS EXAMINER: Mr. Peterson, you may cross-examine.

EXAMINATION OF DR. DOUGLAS IRA HAMMER

Cross, by Applicants

By Mr. Peterson:

Q Dr. Hammer, as I understand it, you have been engaged as a consultant for the attorneys for the Department of Natural Resources to present testimony in this proceeding, is that correct?

A Yes.

Q May I have the amount of your consulting fee, please?

A As I understand it, my consulting fee will be $350.00 a day plus expenses and travel.

Q How many days have you worked on presenting this testimony up to the present time?

A It took me a day and a half to prepare the testimony.

Q Dr. Hammer, I'd like to call your attention to page 3 of your statement, beginning at line 26, wherein you state that "different philosophies must prevail when one thinks about the public health rather than occupational health," and you further state that "people walking around in the ambient environment do not bear such relationships to the general environment" in terms of risk from exposure. By this, do you mean that in general it's acceptable to have a higher level of pollution in an occupational setting than in a general environment, simply because people walking around in the general environment, gain no benefit from the pollution to which they are exposed?

A No, what I meant was simply this, that traditionally, people who specifically receive some economic gain from their work in our society, were traditionally implicitly permitted to take the larger risk with regard to their receipt of income or economic gain than we would a person in the general environment, so therefore, the philosophy of protection must be different for occupational people as well as for the general population.

Q What, in your opinion, are the cost benefit trade-offs that the general population should make in terms of health effects and air pollution, if any?

A Well, I think that the cost benefit trade-offs are a constant that everybody uses but are, No. 1, difficult to find -- to define -- also, extraordinarily difficult to get precise estimates for with regard to not only general health, but often, specific occupational health problems. I think that all of us have to eat and have to sleep and have to be comfortable, and we have to work. We also need certain kinds of energy. I personally think that there should be ways to reach all of these goals. I think, if anything, traditionally and historically, with respect to both occupational health and environmental health, the general tendency has been to go for short-term gains, which profited smaller groups of people rather than considering the general public at large, and this is not only true in environmental health, but it's certainly true in the history of occupational health.

Q On page 8 of your testimony, beginning at line 7, you make a comment about the disagreement between two supposedly equally trained scientists relative to the health effects of air pollution. Now, by this statement, do you mean that the human response to air pollution is so ill-defined and so diffuse that in general, these trained individuals find it difficult to reach a consensus on a defensible position on the human responses from air pollutants?

A What I meant there was that two people who may have -- and this, of course, as you know, is one difference between the written word and the qualifiers of the spoken word -- but by equally trained, I meant two people, for example, who may be both physicians or both health experts or both people with the same paper credentials -- but nevertheless, all of us know that there are doctors and there are doctors, and there are lawyers and there are lawyers; that's simply because sometimes people, No. 1 , have degrees, but they may not have the same intellectual knowledge of that situation, and secondly, there are occasions in science, because knowledge is imperfect, where people do have some question, honest disagreement, about certain effects. I think something I might point out now, because I did have the opportunity to read Dr. Coluccci's testimony, is, for example, comparing my testimony to his, would not be the equivalent of equally trained people, because whereas I think my expertise would properly be in the field of health and medicine, that his expertise would not be there, so that in comparing our statements, it would not be a comparison of equally trained people.

Q You don't, then, consider him to be as good an expert as you?

A Well, I consider him to be a very competent biochemist, which is what he was at EPA, but I was rather surprised to read his testimony with regard to health effects, because he's generally not regarded as a health expert, nor did he function as a health expert for the Environmental Protection Agency.

Q You will concede, will you not, that there are physicians of equal training with you who have different opinions from you relative to the interpretation of various data on air pollution matters?

A Very few. I think what I would concede is that there are probably many physicians that have equal general medical training that probably wouldn't even be competent to testify with respect to environmental epidemiology, because this isn't their special field. I don't think that there's much difference between my opinion and some of the other epidemiologists in the country.

Q Go to page 9 of your statement, Dr. Hammer, and on about line 12, would you cite for the record the studies which you have suggested that the original standards have even less of a margin of safety than thought at the time that they were adopted? Which studies do you rely on for that statement?

A I can't think of the specific reference, but it was either in the hearings of the Muskie Committee or else the National Academy of Sciences, when people looked at the levels at which effects were supposed to occur, compared to the level of the current standards.

Q What were the low ambient levels that you discuss on line 13 of your statement in terms of numbers?

A Well, for example, the standards of 80 micrograms per cubic meters in annual average for sulfur dioxide and 75 micrograms per cubic meter as an annual average geometric mean for total suspended particulate matter, quite frankly, I think that 10 or 15 years ago, if you had asked someone who was knowledgeable in the field of air pollution, would we get a consistent set of information, which would really suggest that these effects occurred at or near these levels, I think a lot of people would have said that that's not likely, because the epidemiological data turned out to be in some ways very different than experimental data, but I think the bulk of the evidence from that time has made it very clear that effects do occur at these levels, and that had you not done the epidemilogical studies, you might never have found that out.

Q How much lower should they be?

A I don't think anybody can say now how much lower they should be, because I don't think the information has been done to tell whether or not one can make them lower. I think one can say that there's a possibility that effects may be occurring below the standards, but I don't think there's sufficient information from an expert to make that -- I certainly couldn't give you that opinion as an expert in the field.

Q On line 20 on that same page, I wonder if you would cite for me the studies which you suggest that if you control pollution, one finds health benefits, and discuss, if you will, what is meant by health benefits?

Q First let me discuss what I mean by health benefits. From the point of view of preventive medicine, one, of course, wishes to search out causes of disease and whether they're environmental or infectious, or what have you, and then, of course, in terms of control strategy, ideally, one would like to prevent all diseases; if not primary prevention, one would like to do what is called secondary prevention or early clinical intervention, but of course, the key thing about intervention is that intervening should have an effect on the outcome of the disease and in some way should reduce either the morbidity or the mortality of the disease process, and I think the best analogy, the best modern analogy, is that in terms of cigarette smoking, that most people who have studied the field in epidemiology, feel there's very strong association to the effect of being causal between cigarette smoking and lung cancer, as well as cigarette smoking and chronic respiratory disease. Now, if that's true, then one's first reaction is, well, we need to get people to stop smoking, and of course, there are two kinds of people you want to stop smoking. One, of course, are people who already smoke, but the other class, using a poetic license, is the people who haven't started smoking yet, but for people who already smoke, somebody may ask the legitimate question, No. 1,with people who have started smoking, even if they stop, will this affect their risk for lung cancer and chronic respiratory disease?

Q What's the answer?

A The answer is yes, absolutely, within a few years the risk of lung cancer and chronic respiratory disease for an ex-smoker comes very rapidly back to that of a non-smoker, so that even though from a practical viewpoint, it's very hard to get people to stop smoking, as it is to get them to stop drinking, from a theoretical point of view -- and I'm not on the rampage, and I notice that several people on both sides here are puffing away at various types of --

HEARINGS EXAMINER: Let the record show that Mr. Bellingham, Mr. Shenker, and Mr. Wicks--

MR. BELLINGHAM: Let the record also show that the Hearings Examiner didn't make any reference to people chewing tobacco.

HEARINGS EXAMINER: The gentleman hasn't testified to that yet.

A Well, I'd be glad to mention it. Actually, there is an increase risk for chewing tobacco for upper respiratory cancers, but I didn't mean to get into ad hominem arguments, Your Honor. The question is, shall we get people to stop smoking, will this really change the risk for lung cancer and chronic lung disease, and the answer is yes, it will, and I think the same thing in terms of environmental pollution holds true. There's one class -- you know, the equivalent of people who haven't started smoking, of places that are already clean, you know, should you let them get dirty, and of course, I think the answer there is very clear, if high levels cause disease, then you should not let them occur. But another question is, does it pay to make -- to spend large sums of money to ask industries to clean things up -- well, will there be any decrease in the excess illness that we see, and I think that from what evidence is available, it does suggest that. I would also like to point out now that it took about 20 or 25 years to get a reasonable body of knowledge with regard to the effects of environmental pollution, ambient air pollutants, and I think it may take somewhere near that long to get quite the air-tight case that it has to do with the health benefits, so what I mean by health benefits is that if you control pollution, do you see a decrease in illness and sickness associated with high levels of pollution. Now, the studies that I was referring to here offhand are, No. 1, a study from Australia, that is mentioned, I believe, in the sulfur dioxide criteria document, and since I've already searched for the reference, I could only find it anecdotally; I could not find the kind of paper that I would like to have as air-tight evidence or submit in terms of my own behalf. I think it was a study around a smelter in Australia. It was referred to in the criteria document; it was referred to in a book referenced either with John Goldsmith as an editor, or John Goldsmith writing a chapter, but even there, this was then referred to another report which had yet to be published, or the long report was unpublished, which suggested that when the plant was controlled, the prevalence of chronic respiratory disease symptoms decreased around the plant.

Another very important study was done by Dr. Ben Ferris in Berlin, New Hampshire, and this was published in September 1973, issue of the Archives of Environmental Health. In this study he went back to Berlin, New Hampshire after having originally studied a group of adults with regard to chronic respiratory disease symptoms, which are generally cough and phlegm and shortness of breath, and also, pulmonary function testing, and he found in the period of time after he returned there was a decrease in sulfur dioxide levels and pollution levels and at the same time, there was a decrease in the level of these chronic respiratory disease symptoms, and after a very thorough analysis, he concluded that the decrease was probably related to the decrease in sulfur dioxide levels. Now, honestly, if I remember correctly, the sulfur dioxide levels in those studies decreased from about 80 micrograms per cubic meter in annual average to about 50, so that would really be levels near the standard, decreasing to levels below the standard; however, I believe that at the time the study was done, the sulfur dioxide levels were measured by sulfation plates, and I think all of us who have been involved in environmental health research, even though we're not atmospheric chemists, have been told that sulfation plates are not as sensitive a measure of ambient sulfur dioxide as some of the gaseous methods.

There are also some studies -- well, there's one study that I did, of children in New York City, where there were differences in acute lower respiratory disease in children living in high and low pollution areas between the elder children, but not the younger children, and that piece of information is consistent, among other things, with the hypothesis that the older children had been exposed to the higher levels of air pollution, whereas in the two or three years that the younger children grew up in this study there were lower levels of pollution.

Q Well, in your statement, you state that sulfur dioxide is invariably converted to acid sulfate aerosols and other compounds, all of which are considerably more toxic than sulfur dioxide gas per se. Now, my question is, what studies do you know of that have actually measured the physical and chemical characteristics of the particulate sulfate compounds produced from atmospheric sulfur dioxide?

A There are several reviews, one of which was produced by EPA a couple of years ago, on the suspended sulfates. Of course, I'm not an atmospheric chemist and don't know that literature. I also think, in looking at this statement -- I was looking at it last night -- that it probably seems a probability that there are situations where sulfur dioxide would get into an atmosphere where particles wouldn't be there, where it may not be converted to something, but these would be so infrequent that I think, again in a general sense, it would be all right to say invariably.

Q Well, is it your understanding that the toxicity of sulfur compounds is more or less a strict function of their specific chemical properties?

A Well, it's my understanding that the toxicity of all compounds is a function of their specific chemical properties.

Q Then isn't it crucial to identify the physically and chemically characterized sulfates and the ambient conditions before you can make a statement that the compounds are more toxic than the sulfur gas per se?

A Well, there have been experimental studies of sulfur dioxide gas and various particles, and also, mixtures of particles, and these studies have generally shown -- these studies have been done on guinea pigs and other animals -- that some of the other chemical compounds of sulfur dioxide, or sulfur dioxide mixed with particles, tend to be more toxic in these test systems than sulfur dioxide gas per se.

Q What lab study was that?

A Some of Mary Amdur's work at Harvard, I believe, shows that.

Q Is that A-m-d-u-r?

A Yes.

Q And are you familiar with her work?

A Not to any great extent. It's mostly laboratory work. I'm familiar enough to tell you -- not to quote the specific references to you, but if you'll read her work, you'll see that she has done studies of the relative toxicity of sulfur dioxide gas and various kinds of particles, and of course, this was discussed in the original criteria documents for sulfur dioxide particulate matter.

Q Now, when we were talking about cigarette smoking and lung cancer and chronic respiratory disease, in the same vein, could you tell us whether anything is known quantitatively about the contribution of atmospheric pollution to these adverse health effects in such a way as to allow a comparison to cigarette smoking? In other words, can you compare, do you know quantitatively?

A I can give you some estimates.

Q What are they?

A I think that if one took smokers and non-smokers and looked at the effect of the prevalence of chronic respiratory disease symptoms, which are generally considered to be shortness of breath, coughing and sputum production, that generally, heavier smokers have from about three to five times the prevalence of these symptoms than non-smokers. If you let non-smokers be one, then you might say the risk of smoking might be from three to five, and that the risk of ambient air pollution in people would be, on that scale, probably 1½ to 2½, but that the effect of air pollution would obtain for both smokers and non-smokers, so that whether you smoked or not, would not really have any effect upon your risk of chronic respiratory disease from air pollution.

Q Now, is that estimate based on any study that you have given?

A Those estimates are based on some of the CHESS studies, as well as some other studies. Just for the record, the CHESS studies were a monograph published in monograph form by the Environmental Protection Agency in May of '74 on the effects of sulfur oxides on health.

Q Now, on page 11, at line 14, there's a statement there, "As a matter of fact, with data from the Environmental Protection Agency accumulated in the past few years," and then continue on to the end of line 23. Are the studies that you're referring to there with respect to acute lower respiratory disease in children, studies which were carried out by yourself and your colleagues at EPA as part of the CHESS study?

A No, this particular study was a study of children in New York City, and it was published -- it was presented at the American Medical Association Air Pollution Medical Research Conference in December of 1974, and has recently been published in monograph form in a monograph entitled "Clinical Implications of Air Pollution Research," which is available from the American

Medical Association, and the reason why the study is particularly important is that most of the earlier work had been in European or Australia or Asian countries, and consequently, although there were studies of non-Caucasians, there were no studies of non-whites, because most of these countries had very small populations of non-whites. Now in this country, in New York City, we had a large enough sample, as we did in another study I did subsequently, in Birmingham, Alabama, and Charlotte, North Carolina, to study black children as well as white children, and if the effects of -- the intracity differences in lower respiratory disease were really due to air pollution, then I think from the point of view of the epidemiologist, you'd expect non-white children, as well as white children, to be affected. You might suspect that they had some difference in sensitivity to suntanning, but it's really hard to imagine why differences in pigment color would really have great protection from severe pollution, and in both the New York study, as well as the study in the southeast, the risk of lower respiratory disease was high for black children as well as white children in the high pollution areas, as it was for girls, as boys, as it was from children from households with a high school or better education, as opposed to a less than high school education, so putting this all together, I think it argues for the consistency of the effect of air pollution, as opposed to some intervening variable.

Q Were there studies along this same line, then, published, in addition to the CHESS monograph published in 1974 that you know of?

A Neither of these studies were published in the CHESS monograph and I think it's also important to clarify the record, that at one period of time, I think people in Washington and the Environmental Protection Agency needed something to sell or a good moniker, and I think that CHESS started to become that, but for those of us who were working epidemiologists, a lot of these studies were standard epidemiologic studies, and whether you called them CHESS studies or any other kind of study, was as much a matter of administration and politics as it was of substantive epidemiology. The two particular studies I was thinking about here were done under the program at EPA, but neither of them were published in the CHESS monograph. One of them was presented at the AMA meeting and published by the AMA that I've just cited, and the second one has been the substance of my thesis at Harvard and will be published this year, of course, by Harvard, and then probably subsequently by me in the general literature.

Q Since the time of the publication of the CHESS monograph in '74, have there been any findings on this particular subject matter by subsequent studies, that you know of?

A Again -- I guess I'm not making it clear -- but these two particular studies, both of which I was the primary author on -- were studies that have been analyzed and written since that time.

Q Do you know of any other studies besides those two?

A Well, I know of a study that doesn't have to do with sulfur oxides, it has to do with lower respiratory disease and oxides of nitrogen, which also, again, showed consistent effects for -- it did not show effects for non-white children because in this particular study, there was too small a sample, but it showed effects for girls and boys and for children of high school or greater, as well as less than high school. This was presented at the Society of Toxicology meeting in March of 1975, and again, I was the primary author on that, and that report should be available from the Environmental Protection Agency. It's cited in my bibliography as a presentation.

Q Did anyone collaborate with you on that study or that publication?

A Yes. I would guess that it was probably Carl Hayes and Fred Miller and Andy Stagg. At EPA, we tended -- different places have different philosophies with regard to co-authorship. Mine is that people who work with you should get some recognition and one way to do that is to make them a co-author of the paper. It's generally considered that the first or the second or the last author has done --

Q And again, with regard to these studies, on the same page, page 11, at the bottom of the page, beginning at line 24, you state, "In terms of the health effects that are generally associated with increased short term exposures to sulfur dioxide," and then continue on to the next page, through line 10, is the basis of that statement again on the data that was developed in the CHESS studies which were performed by EPA?

A Not really. The basis for this statement was primarily the world literature summarized through 1969-1970 and the criteria documents for particulate matter and for sulfur dioxide, which I think are APCA Publication No. 49 and 50, and the CHESS studies added some information to this, but I think were really incidental to my statement here, just one piece of information. It wouldn't have made much difference either way. There is just a tremendous amount of literature available from many countries regarding the health effects of environmental pollution.

Q On page 12, beginning at line 11, your testimony states that "Of particular concern is acute lower respiratory disease in children because it increases the risk of chronic respiratory disease in later years." Could you cite for me and the record the studies that you rely upon for that conclusion?

A I would have to tell you authors, but I'm afraid I couldn't cite the exact studies right now, although I could certainly submit them to you. The authors were Colley, C-o-l-l-e-y, Reid, R-e-i-d, Holland, H-o-l-l-a-n-d, Colley and Holland being very well-known British epidemiologists and Reid being a very well-known British pathologist, and these were studies of children, very early in life, and then following through in later years, and they found that children who have tended to have higher respiratory illnesses in childhood, when they went back and studied them later in life, tended to still have suggestions of chronic respiratory illness, and this particular idea is not entirely proved, although there's a great deal of evidence to suggest it. I hope that was clear from my statement. This is something that I would put into the category of if not entirely proved, it's well on its way.

Q In regard to that discussion, in part of your testimony on page 13, you state, "If it is true that repeated acute lower respiratory infections in childhood increase the risk of chronic respiratory diseases in adulthood, which I believe it is," -- is that any indication that you're not sure that the evidence is that solid and this is more or less an opinion rather than a fact?

A Well, first of all, I think that anything that anybody says is always an opinion, and I think that it's probably a fact, and the reason for that is this, No. 1, if you look at children who have the most of the acute respiratory diseases in childhood, which are children with a disease like asthma, then it's well-known that these kids do much more poorly as adults with regard to chronic respiratory disease.

Q How do you relate that to air pollution?

A Well, I think the key point of the argument is whether or not children who suffer repeated lower respiratory illnesses in childhood have a higher risk of chronic respiratory disease as an adult. If this is true, regardless of what causes the increased attacks of lower respiratory disease in childhood, this would increase their risk of chronic respiratory disease as an adult, so to the extent that air pollution contributes to the excess in childhood, it also would contribute to the excess risk in adults.

Q How do you begin to calculate the damage function for this?

A Well, that's what I try to point out here, that we haven't even begun to calculate damage function for this, because I think the problem that a lot of us have who are not economists but yet concerned with health care is strictly this; that you know somebody has an illness; you know that there are dollar costs associated with this, as well as social and human costs, and yet it's nowhere near easy to figure out how much it costs in dollars as it is, let's say, how much it costs to run your car for a year, or something like that, so the intention of my comment here, which maybe, if I read it aloud, would make it like it sounds -- (Reads) "If it is true that repeated acute lower respiratory infections in childhood increase the risk of chronic respiratory diseases in adulthood, which I believe it is, then how does one even begin to calculate a damage function for this?" Because not only do you have to calculate whatever the costs are associated with the excess illness attacks of lower respiratory diseases in childhood, but then you either mathematically or economically or something, have to calculate or put a dollar cost to the risk of chronic respiratory disease and the associated burdens of that in adulthood, and I think, to my mind, there's certainly a great risk there, but I have a difficult time putting an actual dollar cost to it, although I'm sure we could probably get some averages. The point is, that it's a large figure, but it's not as easy to get as the equation for a straight line or something like that.

Q Who do you think is qualified to make these cost benefit judgments regarding a disease attributable to pollution as opposed to other stresses in life?

A Well, I think probably people that are trained in calculating damage function and people that are trained in the effects of pollution. From just having worked for EPA for several years and seeing the number of people who have made cost estimates, certainly, their qualifications vary greatly. Certainly, everybody is concerned with health care, whether it's environmental health or any kind of health, because it costs a lot of money, but it's also well-recognized that it's a difficult area to get precise estimates in.

Q You stated that you felt that it would be a large dollar figure. Do you have any numbers you could give us as to the percent of the population of the United States that has repeated acute lower respiratory infections which increase their chronic respiratory diseases in adulthood?

A I don't think I could give it to you this minute. What I could give you, and I think I mentioned it later in my testimony -- perhaps it's earlier -- let me see --

(PAUSE.)

Oh, yes, I think on page 13, from lines, probably from 1 through line 17 -- well, let me start at line 25 on page 12, if I may. Let me just read what I wrote. (Reads) "I would like to say something briefly about the public health cost to the community of air pollution. I agree that what the economists have called damage functions are very difficult to calculate for health, not only for environmercal pollution, but in terms of most things. The other side of this, and I feel very strongly about it because I am a public health physician, is that just because it is difficult to calculate something, doesn't mean that there is no cost associated with it. Respiratory illnesses are the commonest illnesses that man experiences. In terms of children, anywhere from 50 to 85 percent of all the illnesses that children ever have are respiratory illnesses, so that they are frequent illnesses, and even a small increase will get to be a lot of cost in terms of medicine, in terms of work interruptions, and terms of aggravations. This is true not only for children, but for grown-ups, with their acute respiratory illnesses as well. If it is true that repeated acute lower respiratory infections in childhood increase the risk of chronic respiratory diseases in adulthood, which I believe it is, then how does one even begin to calculate a damage function for this? Yet, who among us would say that there is no cost, both economic and social, associated with such a hazard?"

One simple calculation, and I assure you that it's simple, is that the best studies of air pollution have suggested that it's anywhere from 1½ to 2½ increase in risk in acute respiratory diseases for people living in high polluted areas compared to those living in low polluted areas, so let's assume that that risk is just twofold and let's say that if people living in a polluted area had on the average of four to six respiratory illnesses a year, and you double that, then the simplistic approach to that is just double the amount of dollars you would want to give for what it costs for the medicine, what it costs for a doctor, if they saw a doctor, what it costs to stay out of work, and if you want to add -- here's where it starts to get difficult -- what it costs in the interruption in general work and family habits.

Q Are those respiratory diseases to which you've just made reference caused by air pollution, or likely only aggravated?

A Well, I think that depends on what you mean by "caused," to the extent that I think all one can say in modern science is a statement of probability. Given a certain exposure, a certain effect occurs, and acute respiratory illnesses tend to occur more frequently among people living in high air-polluted areas. I think that one of the questions that still remain in air pollution is the mechanism by which air pollution increases acute respiratory illnesses. There are several ways it could do this, because it's well-known for any infectious disease, that everybody that is infected, does not necessarily manifest clinical symptoms. Two extremes of this are, in one extreme, people infected with poliomyelitis virus, who may be less than 10% of the people who have the infection, actually have clinical illness, and probably less than 5% manifest paralytic polio, which those of us who are over 30 would remember to be a thing that used to terrify all of us who are parents of children; on the other hand, another disease, which again, is going to become of historical significance, in this country, is measles, and it's generally regarded that about 95% of the people who get infected with the measles virus get what we clinically call measles, so one has to have a concept -- maybe one way to think of it is the biblical concept of some being called and others being chosen, that more people are infected with an organism than develop clinical symptoms, and that for the acute respiratory illnesses, depending on which viruses and which bacteria, this proportion varies, so then, in terms of postulating mechanisms for how air pollution works, one can wonder if what air pollution actually does is increase the true incidence -- let's say, that for every 100 people infected with a respiratory virus, just for argument's sake, that 70% of these people develop symptoms, something that they themselves, or some physicians would say, "Yes, you have a cold, or you have a sore throat, or you have a lower respiratory disease." Well, there are at least two mechanisms or some combination that conceivably could be affected by air pollution. One could be to increase the total infection rate of people so that the proportion that develop symptoms stays the same, at 70%, but now, instead of affecting 20 people per hundred, maybe 30 people per hundred get infected. An alternate mechanism is that the same number of people get infected, to keep it simple, but now instead of 70% of them developing clinical symptoms, 80% of them develop clinical symptoms. These are areas which are still not well understood, but are certainly both consistent with the hypothesis of the cause of air pollutions, so when you say, does air pollution cause it, I think one has to qualify it.

Q Well, the numbers which you just gave us are just estimates, aren't they? You don't know of any studies that have been done that show the exact numbers of increase because of the aggravation, or caused by air pollution.

A I don't know studies of that, but there are many studies that have been done for specific viruses, to suggest what percent of people develop clinical symptoms. For example, as I mentioned for polios, less than 10%; for measles, it's about 95%; for German Measles and chickenpox and whooping cough, it's about 60%, and for influenza, it runs between 30 and 40 percent given the strain, so that certainly, the literature on what proportion of people who are infected, develop symptoms, is fairly well advanced.

Q Those are all related to disease rather than air pollution, aren't they?

A Yes, they are, but you have to know that, I mean, as a starting point, to know whether or not you would increase or decrease that ratio with exposure to air pollution, as well.

Q Do you know of any case study where the person affected with measles has been aggravated because of air pollution?

A No.

Q You go down in your statement on page 13 again, and you say -- you're discussing the relationship of sulfur oxide and particulate matter to cancer, the genetic effects, to other long-term effects which have not either had ample time for exposure or we do not yet possess the tools to study. Are you suggesting there that there is evidence that sulfur oxide, per se, and particulate matter, have a relationship to cancer?

A Well, if I may, I'd like to read the beginning of this statement, on line 18, through line 24, again, to put it into context, on page 13. (Reads) "There are still areas of uncertainty with regard to sulfur oxide and particulate matter exposure and their health effects. There are areas where we still have little or no information, yet they may be of serious concern. For example, the relationship of sulfur oxides and particulate matter to cancer, to genetic effects, to other long-term effects which have not either had ample time for exposure, or we do not yet possess the tools to study." What I was suggesting here was not necessarily that sulfur dioxide and particulate matter may directly cause cancer or genetic effects, but that this is simply an area of information where we don't know, and I think that in any science, one must distinguish where we do have information and one can say something is not, or is a risk, versus areas where we don't have information about that, and it may well turn out, for example, that sulfur oxides and particulate matter pose a very low risk to cancer or genetic effects, but on the other hand, it could turn out that they pose a high risk. I'm just saying that we don't really know, but if they turn out to pose a high risk, it would be an area of great concern.

Q We don't have any evidence to date, that you know of, that suggests that the sulfur dioxide is the primary synergism for cancer?

A We don't have enough evidence either way to say. No, we don't have any specific evidence that suggests that, but we don't have a lot of evidence that doesn't suggest it, either. It's not been well studied. The point I'm trying to make here is that these are areas where, because they are very serious diseases, we would like to have the answer to them, but we don't have the information either way. It's not where we can safely say that it is or is not a risk.

Q In your testimony, you keep referring, or you have referred, to highly polluted areas. How do you define that term?

A Well, of course, one defines it on a relative scale. Most of the studies that were done were done taking place with various annual average levels of the pollutants, the exceptions being some of the public health disasters that I referred to, like

London, or the Meuse Valley, or Donora, Pennsylvania, where one saw relatively short-term increases of pollution, and with that, horrendous numbers of people dying and getting ill. I used to define that as a relative term. I think the best way to define it is in terms of any given study, to look at the levels of the air within that study and just that -- you know -- depending on whether they have two or three communities, whether they're low, intermediate, or high.

Q I agree that probably it's a relative term. The question now I would like to have you answer is, what were the levels of sulfur dioxide, for example, in Donora or London?

A I think, during the acute episodes, they were probably somewhere between 500 and 750 micrograms per cubic meter, or something equivalent to that, but I would also say, for example, in London, that the same week that levels were that high the same three or four days, there were 4,000 excess deaths, and in Donora, Pennsylvania, there were either 20 or 30 excess deaths, which is not even to discuss the number of people that got sick or went to the hospital or saw their doctor, but those levels were associated with deaths -- I mean, just body counts. 4,000 people is probably twice the size of East Helena.

Q Are there any other examples where that level of pollution has occurred that you know of which has caused those kinds of adverse effects in our history, other than those three you mentioned?

A Well, of course, Donora was in the United States, London, of course, is in England. There was the Meuse Valley in

Belgium, there was an episode in Costa Rica, in South America, but I offhand can't quote the levels to you. I would guess that they were somewhere estimated to be somewhere between 500 and 1,000 micrograms per cubic meters of sulfur dioxide or above, but I could not swear to that, as I said I would at the beginning.

Q Has there been some difference of opinion as to the Donora, Pennsylvania episode as to the exact cause of the adverse effects?

A I think that everybody agreed that it was due to the pollutants in the air. Unfortunately, the monitoring done at that time -- don't forget the Donora episode occurred in 1949, and that we didn't have very sophisticated monitoring devices, so that it was hard to attribute to any particular given pollutant, although certainly, I would feel comfortable in attributing it to the mix of pollutants that were there.

Q Do you feel that the Colstrip plants are going to cause levels of this sulfur dioxide on acute conditions?

A Well, I don't know how high they go. Most of the estimates that I looked at were concerned more with longer term averages. I should hope they wouldn't even come close to causing levels like that, because those are really disaster levels. Most of the estimates I saw suggested that they would be either at or somewhere above the federal standards for sulfur oxides and particulate matter.

Q Dr. Hammer, on page 13, beginning at page 24, and running through the next page of your testimony to the first line, do you mean to say there that you strongly feel that sulfur dioxide can interreact with ozone to produce toxic materials which have an adverse effect upon health?

A What I mean there is that whatever effect sulfur dioxide has on a test system, certainly on plants and even on human pulmonary function, if you take the effect of pure sulfur dioxide exposure at a given level and then the effect of pure ozone exposure at a given level, and you would say, let's say, I have an effect of one from sulfur dioxide and an effect of one from ozone, then if I put these together -- and this would be purely what would be called an additive system -- then I should see an effect of two, and in point of fact, by putting these both together, one sees an effect of more than two, or a so-called synergistic effect, so my point here, I guess, is that although, again, it's very common and people talk cavalierly about studying myriads of pollutants with synergistic effects, I am very comfortable from the public health point of view of at least assigning effects to single pollutants, because we've probably just as much evidence that these combinations can cause synergistic effects as that they can cause additive or antagonistic effects.

Q What studies do you know of that support this relationship, this synergistic effect between sulfur dioxide and ozone?

A Well, there are basically two sets. One is a very elegant set, which has been summarized in the 1969 criteria document for sulfur dioxide under plants, which, of course, are not in the area of my expertise, but these do describe this synergism very well. It's very well understood. The second set are a group of studies done by Dr. Bates and his colleagues, in

Canada, which were originally cited, I think for the National Academy of Sciences meetings in the fall of 1973, and these show a synergistic effect in terms of decrements in pulmonary function related to exposure to sulfur dioxide and ozone.

Q Do you know of any study that has been done by a Dr. Jack Hackney?

A Yes, I do. I haven't seen his most recent work so I don't know what he's found in terms of synergistic effects. I know that he did do some work. The last I saw was probably about a year ago, six months ago, where he did some work on ozone exposure and did find short-term effects with ozone exposure.

Q Didn't those studies fail to confirm the clear synergism between sulfur dioxide and ozone?

A I honestly have not read the studies. They may very well have. I'm just not very familiar with the study. I think, to my mind, the real point here is that there are a lot of people who get exercised about synergisms and say that we can't make any control unless we understand all the synergisms, and I think that that's not true, simply because, for example, if you say that Dr. Hackney's study failed to confirm Dr. Bates's work, then I would certainly accept that for purposes of argument, but I still think there's enough information on sulfur dioxide alone, or ozone as a pollutant, that I don't think I need to wait any longer to make regulatory statements about them, until I understand all their interactions or synergisms. That was really the main point of my statement, although it may not have been clear in the written testimony.

Q You mentioned during your testimony, several studies relative to supporting your thesis, one of which comes from the CHESS information. Are you aware of the recent controversy that has developed along the lines that the CHESS information which purports to support a relationship between health effects and sulfur dioxide may in some ways be inaccurate by virtue of the fact that some of the data was not used, and some of the data was changed?

A Not specifically. I'm aware of the fact that when the studies were reviewed, there were differences of opinion as to -- and of course, this goes back two or three years now, because those studies were sent out to probably a hundred people to review, including corporate people and university people, and also were subsequently reviewed by the Rall Committee, and I think that at that time, the National Academy of Sciences, and even then, they say there was probably some overinterpretation of some of the data, but I didn't interpret it as a blanket exclusion of all data as invalid.

Q Have you read the Task Force Study from the Science Advisory Board?

A Yes, I have.

Q By Wittenberger?

A Yes, I have.

Q And didn't he conclude, or didn't that report conclude that the charges from certain EPA people were that there was overinterpretation of the data and their conclusions were not supported by the data?

A Well, that CHESS monograph probably had 40 or 50 studies, and I don't think the Wittenberger report in any way, shape, or form meant to implicate that all those studies were unsound. I think there's been general concern among epidemilogists of the methods of studying short-term pollutant effects, because this is difficult to do.

Q Do you know, of your own self, your own knowledge, whether or not the published CHESS studies were distorted in the direction of tending to demonstrate more association between sulfur pollution and health than, in fact, really exist?

A I think that the studies that my name is on were not distorted. I think that on one or two of them, if I were first author, I would perhaps have written a slightly different interpretation, but I didn't feel that they were -- this is, you know, a matter of style.

Q Well, then, do I conclude from that that as far as the data set forth in the CHESS monograph of '74 on the health consequences of sulfur oxides, you believe that they're substantially correct?

A Well, again, I guess I didn't make my point clear before. I believe that everybody who is knowledgeable in the field of epidemiology feels that the methods for studying the effects of long-term pollutants exposure are presently more sensitive and more salient on the effect of short-term exposure, and to that extent, I was more comfortable with the long-term effects when the monograph was published than with the short-term effects, as I am now, and I think that never has been any secret to anybody who knows me.

Q Are you aware that there is currently an effort underway in the private sector to examine the validity of all of the data?

A Well, but I think a lot of that is just partly politics and partly sour grapes. I think that if the studies are true, then, of course, it will cost some parts of the private sector a great deal of money, although certainly, other parts of the private sector will make money by pollution control devices, and I think it's a standard -- you know, all these data are available, and at least when I was working for EPA, people who wanted copies of the raw data, we'd gladly, whether they did it under suit or under the Freedom of Information Act, this was gladly supplied. I think that for most of the studies, the analyses were reasonable, and I don't think that the reanalysis is going to show anything, and the reason I say sour grapes is because people publish studies all the time that other people disagree with, and I don't think that the only way to solve that problem is to reanalyze the data, but certainly, the data has been supplied to any legitimate organization that has asked for them, because under the Freedom of Information Act, the Agency is obligated to give out any information that people request.

Q Do you feel that if these experts judge the data to be incorrect, would you still hold them to be valid?

A It depends on who it is. If it were George Hutchinson, or Jim Wittenberger, for Harvard, I certainly would give them a lot more credence than Tony Colucci or some of the other supposed experts that I think, you know, really don't have the training or the experience to make these judgments, and I don't mean it to sound personal. You probably know Tony and I are very good friends, but I think when it comes to health.

everybody's an expert. Those of you who are lawyers probably hear this more than I do, but at the hearings I've been at, especially when public witnesses testify, when someone asks them a legal question, they very clearly say, "Well, I certainly wouldn't answer that, because I'm not a lawyer," and then go on to say everything they think about health effects; not that I'm sensitive about my field, because certainly, health touches all of us, as does law, but I think that -- again, you know, when I worked for the federal government, I was a private citizen. It's the persons who work for industry, for example, like Vaughan Newell, you know, who's also a personal friend of mine, and I put a lot more credence in his opinions than I do in some of the people who work for industry, not because industry is bad and government is good, but some of these people are just better than others, that's all.

Q Do you think that if the data were reinterpreted that a different opinion would obtain?

A I'm not sure exactly what you mean by that.

Q Do you think if someone reanalyzed the data in the CHESS monographs, that a new opinion could be developed?

A An opinion with regard to what?

Q Sulfur oxide.

A I don't think it could be very different with the general effects of sulfur oxide, because I think all the CHESS studies did was to reinforce and extend some of the earlier work. For example, the original criteria document for particulates and sulfur dioxide clearly pointed out that these pollutants were indices of other things in the environment. The side studies about -- for example, there's an excellent study on acute respiratory disease and sulfate exposure in the original criteria document, by Dr. Curtis Dohan, of Philadelphia, and I think Ben Ferris or Jim Wittenberger, or Ben Ferris and Anderson, '65 or '66, published a review of the air pollution literature, and pointed out that as well as measuring SO_2 or TsP, there were other things, such as sulfates and other chemicals that were causing effects, so I don't think that it would -- it might have some -- it might alter some interpretation of the short-term effects associated with asthma or cardiopulmonary disease, but I think, again, for myself personally, I've always had more reservations about those than I've had about the longer-term health effects and exposures, and I think in everything I've written or the few times that I've testified during the past few years, that that's eminently clear in my testimony. I think the short-term areas are still places where we need a lot of information, more than in long-term areas, and I think most people agree with that, no matter who you worked for.

Q With regard to acute effects, what is the available data on which the federal 24-hour standard was based as far as threshold is concerned, do you remember?

A Again, these were set from the information, most of the information reviewed in the criteria documents. There were several studies in there, either people with chronic respiratory disease, such as bronchitis, or during some of the episodes such as the London smog or Donora, or some people with a history of asthma or respiratory symptoms, in terms of prospective studies, and I could cite both the particulate and the SO_2 criteria documents for the review, but I would really have to --

Q You don't have it right here?

A I have it back in my room. I have a list in my briefcase as references of all these documents, which I would be glad to submit to the hearing if you'd like, if it would make it easier for you.

HEARINGS EXAMINER: We'll wait and see what they want to do on cross-examination.

Q Have you ever undertaken any study or used the criteria documents of EPA to determine the effectiveness of the Montana standards?

A Again, I'm not sure of your question.

Q Do you agree with the Montana standards?

A For what pollutant?

Q SO_2.

A I believe that they're lower than the federal standards. I'm not sure exactly. I believe the Montana standard for SO_2 is something in the low 50 micrograms per cubic meter as an annual average, but I would have to check that.

Q Would that indicate to you that they may be sufficient to protect public health?

A I should think that if the standard is about 50, that that certainly would be stringent than the federal standard, and I think that based on current information, it should protect the public health. Again, one never knows, but certainly, it poses less of a risk than an annual average of 80.

MR. PETERSON: I have nothing further.

HEARINGS EXAMINER: Mr. Shenker.

MR. SHENKER: I'd like Dr. Hammer to take a look at the list he was talking about furnishing Mr. Peterson, so if we took a break now, this would be a good time to get the material out.

HEARINGS EXAMINER: All right, we'll take a 10-minute recess.

(BRIEF RECESS COMMENCING AT 10:15 A.M.)

The hearing was reconvened at 10:40 A.M., following a brief recess.

HEARINGS EXAMINER: Be seated, Doctor. We're on redirect examination by Mr. Shenker.

CONTINUATION OF EXAMINATION OF DR. DOUGLAS HAMMER

Redirect, by Department of Natural Resources and Conservation

By Mr. Shenker:

Q Dr. Hammer, I've handed you what has been marked for identification as DNR Exhibit No. 161. Is this a copy of the list which you referred to in your discussion with Mr. Peterson at the end of your cross-examination?

A Yes, it is.

Q Is this a bibliography which you, yourself, have prepared?

A Yes, it is. It's part of a thesis that I prepared at Harvard, but I think it is useful in terms of giving specific references to several of the documents that I've mentioned. Just for convenience, I think I'd like to submit it.

MR. SHENKER: For that purpose, I'll offer DNR Exhibit No. 161.

MR. PETERSON: We have no objection.

HEARINGS EXAMINER: It will be admitted. While we're on this subject, how about 160? Do you have any objections to it?

MR. PETERSON: No.

HEARINGS EXAMINER: Very well, 160 is admitted, too.

Q Dr. Hammer, in your cross-examination by Mr. Peterson, there was a discussion between the two of you on the advantages of stopping smoking or the advantages of decreasing or stopping pollution. Let me ask you, sir, if it were your objective to constitute the minimum adverse environmental impact from a public health perspective, would you want to decrease the emission of pollutants as far as technically possible?

A Yes.

Q You and Mr. Peterson had a discussion with respect to short-term exposures and acute problems as the result of short-term exposures. Is that the same thing as a high peak that is taken into consideration in a long-term average?

A No. I think one convenient way to think about the health effects of environmental pollution are those effects related to short-term exposures and those effects related to long-term exposures. Now, short-term exposures, by definition, and usually, by convenience, are anywhere up to as long as two or three days, depending on which paper it is. Often it's a 24-hour average, and sometimes less than that, and the effects related to that, of course, are health effects you would see within a short time after the exposure. The effects of long-term exposures, of course, have to be a combination of exposure to lower, longer-term averages, and included in that, some intermittent episodic peak exposure levels, and what's not really well-known now is to what combination or what mix of these things you need to get long-term effects. For example, if you take the average year, which is 365 days, and assume that you get valid pollutant information every day, then obviously, the average would be -- let's say, if you have an annual average of 80, which is permissible, then the average has to be made up of -- it could be a daily reading of 80 every day, or, you know, you could have pollution on one day and nothing at all the rest of the days, and still come out with an annual average of 80. What the concern is, is that nobody is sure, especially in circumstances around point sources, where you may get intermittent fumigations, what combination of those you need to produce long-term effects, and the concern is that one could have, could achieve an annual average, or the annual standard, and still have enough short-term excursions so that you're still producing long-term effects, or that you're still in compliance with the long-term standard.

Q For example, you discussed with Mr. Peterson some of the well-known disasters related to air pollution, such as in London and in Donora, Pennsylvania, and you mentioned a concentration in the range of 500 micrograms per cubic meter.

A Or above, I think I said.

Q If one were to assume 500 micrograms per cubic meter for a single day and 78.85 micrograms per every other day in the year, you would hit an 80 microgram average for the year, wouldn't you?

A That's exactly the point I was making, or if you had two days at 500, then it probably would get down to about 76, or whatever it works out to be mathematically, and of course, one could be having health effects even though you're in compliance with the so-called annual average.

Q You and Mr. Peterson also had a discussion about synergism, and I wonder if you might be able to tell us, Dr. Hammer, how does your view with respect to a concern for synergism relate to the control strategies and standards which exist, all addressed to single pollutants?

A I think that synergisms -- and I wonder if it wouldn't be worthwhile giving a very simple definition of synergism and antagonism, because I think they are words that are used often. One convenient way to think about it is that if you have a dose of Compound A and a dose of Compound B, each producing one unit of effect, then if you gave them both together, the effect you would see would be equal to two. This would be called an additive effect. Each part contributes an equal amount to the effect you see. A synergism is when giving the same dose of A plus an equivalent dose of B, you see now an effect that is greater than two, greater than predicted on a purely arithmetic weighting scale, and conversely, if you saw, giving the dose of A plus the dose of B, giving less than that effect, then this would be called antagonistic. Probably a very common example of that is that certain drugs should not be given to people mixed in the same injection, because they tend to precipitate each other out, or inactivate each other so that the overall effect you see is less than that predicted. Now, this brings up another problem, the concept of synergism and antagonism, which is -- you might then argue, well, you're not really giving the actual dose of drug that you thought, so that's why I prefer to think of it in terms of statistical terms, rather than mechanistic terms, and of course, the last category is independent effects, where what you do -- you know, if you give two different compounds, they each have the same simple unit effect, because they're affecting different symptoms that don't have any relation -- different systems, which have no relation to one another.

I think the main concern I have with regard to public health, and I think this is an important point, is that it has often been said, and quite correctly, that measurements such as sulfur dioxide or total suspended particulate matter really may be only indirect estimates of the true thing in the atmosphere that's actually causing the pollution, or actually causing the effect, and I think there are two corollaries to that, No. 1, that until you have a personal monitor for every creature or thing that you study, that any monitoring station anywhere, no matter what the pollutant is, no matter what combination it is, would always have to be an estimate of the dose that somebody gets of that pollutant, and No. 2, one must distinguish things of intellectual interest from things of practical importance. The two are not always the same. For example, it is very clear that people who smoke heavily have high rates of lung cancer. It is very clear that people who don't smoke have low rates of lung cancer, and it's very clear that if you take people who smoke a lot and stop them from smoking, then their rates of lung cancer rapidly decrease to those of people who never smoke. Now, somebody could say, well, the only thing about that is that you never really know what in the cigarette is causing the lung cancer, and the answer is, that's exactly correct, just as at the turn of the century, with the great sanitary movements in sanitary engineering, people put chlorine in water and killed a lot of bacteria whose names they didn't know, but it was very effective, but if you waited to identify every bacteria or if you waited to identify exactly what part of the cigarette smoke is doing it, you would -- I mean, what you do, you forgo something of tremendous public health value, and I feel the same way about environmental pollution, that the literature on sulfur dioxide and particulate matter is abundant and is fairly consistent, and, you know, more than reasonably consistent in terms of implicating these things as effects of pollution, and that what evidence is available, although still not tremendous, suggests that when you decrease pollution levels, you do also decrease the excess morbidity associated with it; then, yes, although it might be interesting to know how these things are interacting, that's no reason to wait to exercise current control.

Q Speaking of the literature to which you now refer, Dr. Hammer, you and Mr. Peterson also had a discussion on literature which seemed to focus rather heavily on the CHESS studies. In the first place, would you tell us what CHESS is an acronym for?

A Yes. It's an acronym for either the Community Health and

Environmental Surveillance System, or the Community Health and Environmental Surveillance Studies, or as we sometimes use to kid around and say, the Confederate Health and Environmental Surveillance Studies.

Q Since it was done below the Mason-Dixon line?

A That's right. I think that's a good point for this reason, that epidemiology research was done in EPA and its predecessor agencies before the CHESS program came along, and the CHESS program meant different things at different times, and there was one point of time where CHESS, at least in EPA in Washington, according to program planning, literally was a way of funneling funds to Research Triangle Park for virtually all of the epidemiology research that was being done, so I think in my mind, you know, those of us who were working in epidemiology always distinguish between what we did and what people were calling it at the time, and there was one period of time when it was a very useful moniker. I still don't think it's unuseful. You know, it was easy to understand and it was a generally good concept. I think, again, that those of us who were working professionals, realized it was oversimplified and that there's a difference between program planning and doing the work.

Q When the criteria documents were published with respect to federal standards -- when was that, sir, in 1969?

A '69 and/or '70. The criteria for particulate matter and sulfur oxides were published in 1969.

Q All right. At that time, there were some folks who were saying, were there not, that the standard of 80 micrograms per cubic meter was excessively low, that there was no reason the standard shouldn't have been at 120 or 130 micrograms per cubic meter?

A Probably.

Q Is anybody saying that any more who is a serious student of the work done on sulfur oxide effects upon the public health?

A Well, I think the reports of Rall and the National Academy of Sciences, and the Muskie report, all have concluded that those standards were reasonable, and in the absence of more explicit information, there's no reason to change them, so the answer is no. I think most people have less of a tendency to say that. I'm sure that somebody is saying it somewhere.

Q Another way of looking at the same concern, Dr. Hammer, is sometimes described as the margin of safety. Can you comment on whether the margin of safety with respect to the standards as set in the Federal Register have been viewed differently with later work that has been done since 1969 and 1970?

A Well, to the extent that the later work all reinforces the initial standards -- and of course, again, now, this is the difference between lawyers and scientists -- lawyers always write the law and they say, what do you mean by margin of safety, and we say, well, I don't know -- you're the guys who wrote the law, so it depends on what you mean by margin of safety, but one simple way to calculate it is calculate what the standard is and what the next highest level above that is, where effects are suspected, and I think in all these standards, it is a very small, if any, margin of safety.

Q Has that become more clearly focused as the result of subsequent work?

A Only to the extent -- and again, I speak in my knowledge of working for EPA, but certainly beyond my bounds of expertise as an epidemiologist, but of course the original problem was just the problem of getting the information to set the standards themselves. Now, the law also talked about review and margins of safety, and I think that in later years, people then began to sit down and look at that, so I think -- I'm not sure whether the same effort went into thinking in margins of safety initially as it did to just setting the levels of no effects.

Q The greater effort, therefore came later?

A Yes, any effort, actually.

Q The law also required you of EPA days to continue the review of the information at hand and which could be generated, isn't that true?

A Yes.

Q So after the publication of the criteria documents and after the publication of the CHESS monographs, would it be correct that you and your colleagues continued that work as the law required of you?

A I'm not sure, but I think it was required as an annual update of the information.

MR. SHENKER: I have nothing else at this time. Thank you very much, Dr. Hammer.

HEARINGS EXAMINER: Mr. Peterson?

MR. PETERSON: Just a couple questions.

Re-cross, by Applicants

By Mr. Peterson:

Q When you were discussing the margin of safety concept with Mr. Shenker, you were relating that, were you not, to the federal standards?

A Yes.

Q And you do concede, do you not, that the present status, the present data, the present evidence bank, shows that there still is some margin of safety in those standards, even though it may be less than what was thought in 1969?

A Depending on the standard, yes.

MR. PETERSON: That's all.

HEARINGS EXAMINER: Anything further, Mr. Shenker?

Re-redirect, by Department of Natural Resources and Conservation

By Mr. Shenker:

Q What are the standards with which you have any concern, Dr. Hammer?

A Well, since we were talking particularly about sulfur oxides and particulate matter, I was thinking about sulfur dioxide and particulate matter standards.

MR. SHENKER: All right, thank you very much.

HEARINGS EXAMINER: Anything further, Mr. Peterson?

MR. PETERSON: No.

HEARINGS EXAMINER: Very well, you're excused, Doctor. Thank you for your attendance and testimony.

(WITNESS EXCUSED.)

HEARINGS EXAMINER: The next witness.

MR. SHENKER: As the next witness for the Department of Natural Resources and Conservation, we call Dr. Clarence C. Gordon.

DR. CLARENCE C. GORDON, called as a witness by the Department of Natural Resources and Conservation, having been first duly sworn upon his oath, both as to his written direct testimony and as to the oral testimony to follow, was examined and testified as follows:

HEARINGS EXAMINER: Mr. Shenker?

MR. SHENKER: At this time the Department of Natural Resources and Conservation will offer the direct testimony of C. C. Gordon which has previously been furnished, and in connection therewith, through the testimony of Dr. Gordon, we would offer Exhibits 220, 221 A and B, 222, 223 A, B, C and D, 224 A, B, and C, 225 A through F, 226 through 231, 232 A, B, C, D, and E, 233 A through F, 234 through 239, and 240 A through M.

HEARINGS EXAMINER: All right, you have Exhibits 220, 221 A and B, 222, 223 A, B, C and D, 224 A, B, C, 225 A through F, 226 through 231, 232 A through E, 233 A through F, 234 through 239, and 240 A through M. Very well, thank you.

(THE WRITTEN DIRECT TESTIMONY OF DR. C. C. GORDON WAS DIRECTED TO BE INSERTED AT THIS POINT.)

TESTIMONY OF C. C. GORDON

ON THE FEASIBILITY OF SITING THE PROPOSED COLSTRIP UNITS #3 AND #4

AT COLSTRIP, MONTANA

My name is C. C. (Clancy) Gordon (personal vita presented in Exhibit 220) and I reside at 1650 Madeline Avenue, Missoula, Montana. From 1960 until present I have been employed at the University of Montana where I am currently a Professor of Botany and Director of the Environmental Studies graduate program, which has 40 graduate students working for a M.S. degree in the field of Environmental Studies.

The testimony presented herein is based upon three factors: (1) the numerous air pollution studies which the personnel of the University of Montana Environmental Studies Laboratory and I have carried out since 1963; (2) the baseline studies on terrestrial vegetation and animals which we have performed in the vicinity of Colstrip, Montana, for various state and Federal agencies from 1972 until present (Montana Departments of Health and Environmental Sciences, Natural Resources and Conservation, Fish and Game; the United States Environmental Protection Agency [EPA], Energy Research and Development Administration [ERDA], and the U.S. Forest Service--Region 1). Factor (3) is the combined data gathering, analysis, and interpretation of vegetation and animals that we at the University of Montana Environmental Studies Laboratory (EVST) used in collaboration with the personnel of six other laboratories whom we worked with in our Colstrip studies (Ames Reactor Laboratory, Iowa State University; Battelle Pacific Northwest Laboratories, Richland, Washington; Natural Resources Ecology Laboratory, Fort Collins, Colorado; EPA/NERL Laboratories, Corvallis, Oregon; U.S. Forest Service Forest Pathology and Entomology

Laboratory, Region 1, Missoula, Montana; and Range Management Laboratory, Montana State University, Bozeman, Montana).

My testimony is separated into eight sections. One section (VIII) is my summary and conclusion on the feasibility of siting the proposed Colstrip Units #3 and #4 at Colstrip, Montana. Because I am using substantial amounts of data, only summarized data is included in the main text of the testimony, and other pertinent data is included in the attached exhibits.

Sections of Testimony

I. Ecosystems of the Colstrip area and the agricultural base of Eastern Montana which will be impacted by Colstrip Units #1 through #4 and other proposed power plants sited in the Fort Union Basin.

II. Acute and chronic air pollution caused damage to the vegetation in the vicinity of coal-fired power plants which emit various concentrations of phytotoxic emissions (Billings, Montana; Mount Storm, West Virginia and Maryland; Paducah, Kentucky).

III. Environmental Studies Laboratory study design, study plots, and baseline data gathering.

IV. Biological and physical impact of sulfur dioxide (SO_2) upon the grassland biome of the Colstrip area.

V. Biological and physical impact of coal-fired power plant emissions upon the coniferous trees of the Colstrip area, including the Custer National Forest and the Northern Cheyenne Reservation.

VI. Acid precipitation and its effect upon the ecosystems of the Colstrip area and other areas of the Fort Union Basin.

VII. Potential damage to indigenous and domestic animals by gaseous and particulate emissions of coal-fired power plants

VIII. Summary and conclusions of siting the proposed Colstrip Units #3 and #4 at Colstrip, Montana.

SECTION I: LAND USE AND ECOSYSTEMS OF SOUTHEAST MONTANA

The southeast portion of Montana, as designated by the Montana Department of Agriculture statistical reporting service, consists of seven counties which include Rosebud County where the town of Colstrip is located. In 1973 the cash receipts for crops and livestock raised on the ranches and farms of this seven county area was $110,042,600, which was 10 percent of the total receipts for the marketing of all agricultural crops of Montana for that year. The average income from agricultural crops and livestock per ranch or farm in the seven county area in 1973 was $50,380, which is 10 percent higher than the state average for farms and ranches.

Rosebud County ranks 5th in the state for cattle production, 13th for sheep production, and 23rd for all agricultural production for the 56 counties of Montana. In 1973 the 62.9 million acres of farmland of Montana accrued cash receipts and goverument payments of $1,139,000,000 which comprised 46 percent of the total income for Montana, and ranked agriculture as Montana's leading industry. Nationally, Montana agriculture in 1973 ranked 8th in production of beef cattle, 6th in sheep and lambs, 1st in strip cropping, 5th in all wheat production, 14th in all hay, 2nd in barley, 4th in flax, and 10th in sugar beets.

Agricultural statistics which are not available in the annual statistics reports by the Department of Agriculture, but are also pertinent to evaluating the real and potential impact of coal-fired power plant emissions upon agriculture in this area of Montana, should also be considered. One such example is the pollinating insects which are extremely important to various agricultural and indigenous species of vegetation. One such insect is the honeybee, which is extremely important to not only Montana's agriculture, but also to that of other states where some of the bees are taken in the winter for pollination purposes.

In 19[illegible] Montana was [illegible]th in the nation for total yield of honey and 2nd in the nation for yield of honey per colony. There are approximately 80,000 honeybee colonies in the State of Montana during the growing season (May to October), 8 percent (6,600 colonies) of which are located in our baseline study area (southeastern Montana seven county area plus Treasure and Bighorn Counties) of Colstrip. The southeast Montana area beekeepers harvest from 100 pounds up to 150 pounds of honey per colony annually, which when using the low production figure (100 pounds) is 660,000 pounds that has a wholesale value of $303,600 and a retail value of approximately $627,000. Dr. Floyd Moeller, Research Leader of the North Central States Bee Laboratory at the University of Wisconsin, states that the economic value of honeybees as pollinators is twenty times their value as honeymakers. Using Moeller's estimation, the 6,600 colonies in the southeast area of Montana are worth approximately $6 million annually (using wholesale prices of honey) just for pollinating purposes.

Timber Resources

The dominant tree species in Southeast Montana is ponderosa pine, which grows throughout the area and has numerous known and unknown influences upon the understory species of vegetation, fauna, insects, etc. and the physical environment of soils, soil moisture, nutrients, etc. Ponderosa pine is the only tree species utilized for timber production and sales in this part of Montana, and accurate data on timber sales on both the Custer National Forest and the Northern Cheyenne Reservation can be obtained by all interested parties.

The Custer National Forest consists of 437,000 acres and has approximately 324 million standing board feet of timber. The annual allowable cut on the Custer Forest is 4.1 million board feet which has a wholesale lumber market value of $738,000 ($180.00 per 1000 board feet). The Custer National Forest is used extensively by the ranchers in the area as grazing lands for 16,000 to 18,000 head of cattle. The cash receipts for grazing these cattle based upon animal unit months is $144,000 per year ($1.20 per 120,000 animal unit months, 1974-75 data) for the Custer National Forest.

The timber resources on the Northern Cheyenne Reservation are located on 131,870 acres of which 129,808 acres are trust lands and 2,062 are non-trust lands. There are 371 million board feet of timber on the above acreage and the annual allowable cut is 4.7 million board feet, which has a wholesale value as lumber of $846,000. The Northern Cheyenne Tribe receives approximately $55,000 annually from the two lumber companies in the area (Ashland Lumber Co., and Black Lumber Co.) for timber sales, which ranks it second in income for the tribe. The largest single income for the Northern Cheyenne tribe is accrued from cattle grazing costs.

Indigenous Vegetation Ecosystems

According to studies by Ray Brown (Ecologist, U.S. Forest Service, Logan, Utah), there are 16 major vegetative ecosystems in the Fort Union Basin (see Exhibits 221-A & B) four of which are present in the seven county area of Southeast Montana (see Exhibit 221-B). The four ecosystems are (1) short-grass prairie, (2) mid-short-grass prairie, (3) grassland-sagebrush, and (4) ponderosa pine forests. While there are hundreds of indigenous species of plants (thus micro-communities) growing within each of the four major vegetative ecosystems of this area. Brown's classification relates to the dominant specie(s) and do not imply to the reader a lack of species diversity.

Collectively, we of the Environmental Studies Laboratory, University of Montana, and of all the other research laboratories we collaborate with in our baseline studies of Southeastern Montana, are working with a rather small number of plant species (approximately 40 to 50) which are actually present within the ecosystems of this area. However, the species which we and others are working with are considered to be either (1) the major producer, (2) the dominant species, or (3) the best biological indicator of air pollution damage. In Exhibit 222 are the common and scientific names of the eight species of vegetation which we here at the EVST Laboratory have concentrated on most during our four years of study in Southeastern Montana.

Of the eight species we are concentrating our studies on, ponderosa pine is considered at this point in time to be the most susceptible to the damage causing effects of the phytotoxic gases and particulates released from coal-fired power plants. There are other species of plants in Southeast Montana which are known to be more susceptible to air pollution damage such as various species of lichens, which also have been studied in this area during the last one and a halt years.

SECTION II: ACUTE AND CHRONIC AIR POLLUTION-CAUSED DAMAGE TO VEGETATION IN THE VICINITY OF COAL-FIRED POWER PLANTS WHICH EMIT VARIOUS CONCENTRATIONS OF PHYTOTOXIC EMISSIONS

During the last six years we have had the opportunity to do a few studies around coal-fired power plants located in three different areas of the United States: Mount Storm area of West Virginia and Maryland; Paducah, Kentucky; and Billings, Montana. In two of these areas (Mount Storm and Paducah), acute fumigation episodes from coal-fired power plants which caused severe plant damage in a one- to three-day period were investigated by several air pollution researchers from various areas of the U.S., including me. Rather than going into a lengthy discussion here in my testimony on the acute damage to vegetation which occurred in both areas, I have enclosed in Exhibits 223-A through D the individual trip reports submitted to Kirk Foster, Deputy Director, Division of Stationary Source Enforcement, U.S. Environmental Protection Agency, regarding the Paducah, Kentucky, acute fumigation episode. These were submitted by Dr. Walter W. Heck, Research Leader, Southeast Region, Agricultural Research Service, U.S. Department of Agriculture, and me. Regarding the Mount Storm acute fumigation episode, reports were submitted to Mr. Foster by Dr. John M. Skelly, Plant Pathologist and Associate Professor, Virginia Polytechnic Institute and State University, Virginia, and me. I strongly urge the members of the Montana Board of Natural Resources and Conservation to read these four reports so they can better ascertain for themselves some of the numerous problems which the farmers, researchers, and state and Federal agency personnel have to deal with in areas where coal-fired power plants are operating to cause damage to agricultural crops.

The major air pollution problem in the Mount Storm area of Maryland was not, however, the acute type which one reads about in John Shelley's, [illegible] reports, but was the slow, insidious chronic plant damage caused by air pollutants (i.e., SO_2 [sulfur dioxide] HF [hydrogen fluoride], NO_x [nitrogen oxide], O_3 [ozone], and particulate matter). This damage occurred, the majority of times, at ambient air concentrations well below any and all state or Federal standards. This plant damage which occurred in the Mount Storm area, as well as in the Billings, Montana area, occurred during extended periods of "low" (below Federal standards) concentrations of phytotoxic gases. I wish to emphasize this point during the remaining portion of this section.

1. Mount Storm

During the period of 1970-71 an intensive study of the air quality, air pollution sources, and plant damage, was undertaken by EPA personnel and their consultants in a 250 square mile area of the Mount Storm area of West Virginia and Maryland in which the major crop is Christmas trees. The one-year, quarter million dollar study was published by EPA and presented at an air pollution abatement activity at Keyser, West Virginia, in April of 1971 (EPA Publication #APTD-0656) This study disclosed that the Federal ambient air concentrations (hourly readings) of SO_2 and NO_x were never exceeded in a one hour period, let alone a 3- to 24-hour period at the three Christmas tree farms where the monitoring stations had been located. These EPA studies also revealed that air pollution damage did occur during that period to Christmas trees at two of the locations where the monitoring stations were located. The major types of visible damage that occurred to these Christmas trees has been presented in published form by Phillip Tourangeau, my research associate, and I in three different publications which are presented in Exhibits 224-A through [illegible]. One of these articles, "Biological Effects of Coal-Fired Power Plants," was edited by Dr. Wilson Clark, a member of the BNRC Board, for the annual Montana Academy of Sciences meeting held in Billings, Montana, in April of 1975. In that article, the reader will find (Page 518) the compilation of the EPA air monitoring data for the Mount Storm area during 1970-71. These compilations show that, indeed, the concentrations of phytotoxic gases in the Mount Storm area are not much different than that found in Billings, Montana, today.

During the period of 1971 until 1973, EPA awarded our EVST Laboratory at the University of Montana a $16,000 contract to perform a study in the Mount Storm area to determine the causal agent(s) which were causing several growth abnormalities to the species of pines grown in the area, the cause of the premature needle casting, and thus the poor and unhealthy growth of the Christmas trees. During that period of 1971-73 our studies demonstrated that SO_2 in the ambient air of the region, while below Federal and state standards, continued to cause tip necrosis (death) to the needles. We also demonstrated that the acid rains in the Mount Storm area caused two of the growth abnormalities and also the premature needle casting. The acid rains which were present in the area (see Page 519 of "Biological Effects of Coal-Fired Power Plants" in Exhibit 224-C) are caused by strong acids such as H_2SO_4 (sulfuric acid) or HNO_3 (nitric acid), which Phillip Tourangeau will discuss in his testimony to this Board

During the period of late 1971 to late 1972, four of the Christmas tree plantation owners and operators in the Mount Storm area brought lawsuits for damages to their trees against three large utility companies and one pulp and paper mill which operated large stationary sources of phytotoxic gases within a 50 mile radius of the Christmas tree plantations. Up to this time (February, 1975) the Christmas tree growers have collected $470,000 in damages from one of the utility companies (both in-court and out-of-court decisions), and $25,000 in an out-of court damage settlement from the pulp and paper mill. The last damage suit against the other utility company (which operated three of the coal-fired power plants, 25 to 50 miles from the plantations) is still pending in Federal Court in Baltimore, Maryland. The amount of air pollution damage and the in-court and out-of-court monetary settlements in the Mount Storm area are not very important or relevant to Montana. What is important to Montana and the siting of Colstrip Units #3 and #4 are the long-term consequences to agriculture and the farmers of the Mount Storm area.

The continuing damage caused one plantation owner to abandon his Christmas tree business and go into a new business. It caused another plantation owner to abandon three large damaged plantations and put all his efforts into the one plantation which was least affected by the air pollution in the area. The economic loss to these two individual Christmas tree plantation owners was not only because of air pollution damage, but also because once the wholesale Christmas tree buyers in the area heard of the damaged trees in the Mount Storm area they either (1) did not buy or (2) bought very selectively or at lower prices when they purchased trees from the plantation owners who had brought damage suits against the utility companies. This is an extremely important point that the members of the DNRC Board should take into consideration when considering the siting of Colstrip Units #3 and #4. Farmers and ranchers know very well that once they make a public claim that their crops or livestock have been damaged by air pollutants or any other causal agent, the chances of their agricultural products being bought at the normal going market price, or bought at all, are greatly reduced. There is abundant evidence that this is occurring here in Montana around the following stationary sources of air pollution (where we at the EVST Laboratory have performed studies on air pollution damage): Columbia Falls, East Helena, Garrison, and Ramsay.

2. Billings, Montana

In our original 1974 report to Dr. Albert Tsao on our contracted baseline studies in the Colstrip area for the Department of Natural Resources and Conservation, we spent considerable time demonstrating that the current air pollution emissions from stationary sources in Billings and Laurel, Montana, were very similar to those predicted by Westinghouse personnel for Colstrip Units #1 and #2. Furthermore we demonstrated, using Westinghouse data on Colstrip Units #1 through #4, that the projected emissions of these four Colstrip units would be from two to four times greater for SO_2 and NO_x than currently occurring in Billings and Laurel, Montana. Also we demonstrated with very accurate predictions that the amount of fluoride which would be emitted by Colstrip Units #1 through #4 is approximately equal to the fluoride emissions in Billings and Laurel during 1973.

In Billings and Laurel, James Glenn, Director of the Yellowstone Air Pollution Agency, carries out year-around air pollution monitoring at several locations in the vicinity of the large stationary air pollution sources as well as in downtown Billings. Glenn's air pollution data is available to all interested individuals, and should be examined carefully by those interested in the ambient air concentrations of phytotoxic gases in this area when trying to predict what is going to occur in the vicinity of Colstrip if or when Colstrip Units #3 and #4 go on line.

If one examines Glenn's data on ambient concentrations of SO_2, NO_x, and fluorides in the Billings area, one notes that the Montana State ambient air secondary standards for these three phytotoxic gases are rarely if ever exceeded during the growing season of the year (April to November). Furthermore one will note that the annual SO_2 concentration in Billings during 1973, 1974, and 1975 is half (.01 ppm) of Montana's annual secondary SO_2 standard, and that the fluoride ambient air levels do not exceed the 1 ppb which is the State standard for any given period and time of the year.

Therefore, according to those individuals who believe that our Montana ambient air standards protect the health and welfare of our citizens and ecosystems, one would not expect to find air pollution damage to the vegetation in the Billings area. During the last one and a half years we at the EVST Laboratory have established two permanent study plots in the Billings area which we use to compare with various types of baseline data we have continuously gathered at over fifty study sites within 125 miles of Colstrip, Montana, during the last four years. Our studies in the Billings area, unlike those eyeball examinations by Dr. Peter Edmonds of Westinghouse Corporation, consist of over 500 sulfur and fluoride chemical analyses of the vegetation collected in Billings, as well as numerous histological studies on the damage to ponderosa pine needle tissues collected from the area. We also performed careful examination of the pathology, insect damage, and needle retention of the foliage of the trees at both of our Billings sites.

Our two Billings sites are located on Snook's property on Sacrifice Bluff (GB-1) and at Frank Kampfe's property in the Billings Heights area southeast of Billings (GB-2). The GB-1 site is approximately 500 meters east of the 180 megawatt Corrette coal-fired power plant, and we have five permanently tagged ponderosa pine study trees at this site. The permanent metal tags on these trees show the following numbers: F-2051A, F-2056A, F-2061A, F-2066A, and F-2071A. There are five permanently tagged ponderosa pine trees at GB-2 site which receive the same types of analyses as those at GB-1 site. There are also 100 ponderosa pine trees in the Colstrip area which are permanently marked trees, and which receive the same type of critical analyses as have the pines at the Billings ponderosa pine sites.

The chemical analysis data from the Billings GB-1 site demonstrates that the sulfur levels in ponderosa pine needles exceed that of the Colstrip area sites by 35 to 100 percent, and that the fluoride levels in and on the Billings pine foliage exceed that of the Colstrip sites (except right in the immediate vicinity of the town of Colstrip) by up to 100 times more fluoride (2 ppm vs. 206 ppm).

The analysis of needle retention at the GB-1 Billings site discloses that the needle retention for 1972 foliage is only 54 percent in comparison to 84 to 95 percent retention for the 1972 pine foliage at the [illegible] percent needle retention for the 1973 pine foliage at GB-1 Billings sites is only 52 percent in comparison to the 92 to [illegible] percent needle retention at the Colstrip sites. Just [illegible] percent needle retention is the percentage of healthy needles or those needles being retained on each previous year's growth (based upon the examination of 100 needles from upper crown of the trees and 100 needles from the lower crown of the trees). For instance at Billings GB-1 site, of the 54 percent needles being retained on the 1972 year's internode (each year has one growth internode) 82 percent were damaged, and of the 52 percent 1973 needles being retained at GB-1 site 78 percent were damaged. If one compares this to the percent healthy or damaged for similar year foliage at the Colstrip sites, one notes the dramatic difference between the polluted Billings area and the clean Colstrip sites. For instance, at the Colstrip sites, of the 84 percent to 95 percent 1972 foliage being retained by these trees, only 30 to 40 percent were damaged

The majority of damage to pines at the Billings GB-1 site is typical tip burn caused by air pollution and basal necrosis of the needles beneath the fascicular sheath. Histological studies of both the necrotic tissue of the needle tip and bases revealed that the tip burn was being caused by gaseous fluoride and sulfur pollutants and the basal tissues were being destroyed by acidic solutions. Chemical analysis of the needles from the Billings GB-1 site was performed after they had been dissected into five different portions of 1" needle tip (see Exhibit 225-A through F), 2" to 3" of middle of needle, and the needle base with and without sheath. The results of the sulfur analyses demonstrated that the atmospheric sulfur, once it enters into the needle, is translocated rapidly throughout the entire needle and most likely out of the needle into the stem. This means that sulfur accumulation from the polluted Billings atmosphere is not usually significantly higher in the tip portion (where the needle tip necrosis occurs) than in the middle needle portions. Sulfur accumulation is less in the basal needle tissues (basal tissues without sheaths) than anywhere else in the needle since this area lacks chlorophyll. The sheath, as previously discussed in our original 1974 report to Dr. Albert Tsao of the Department of Natural Resources and Conservation, is the Achilles' Heel of pine trees, since it collects soluble and insoluble sulfur and fluoride particulate matter which falls out or rains out of the atmosphere. It falls onto the needle and lodges on top and underneath the fascicular sheath where it causes the burnout (necrosis) of the basal needle tissues. Photographs depicting this burnout or necrosis of the basal needle tissues from the Billings, Mount Storm, and other areas of the U.S. are presented in Exhibits 240-A through D, as well as photomicrographs which demonstrate the type of tissue pathology manifested in pine needles from acidic solutions under control conditions and in nature.

Results of fluoride analyses of the pine foliage, grasses, and forbs from the Billings GB-1 site disclosed that a very serious fluoride pollution problem occurs in the Billings area on the Snook property, and that this is occurring even though there is no evidence that the State of Montana ambient air fluoride standards are violated. However, the forage and ponderosa pine foliage on the Snook property exceed the State standard of 35 ppm, and the evidence that the Corrette coal-fired power plant is the major polluter of the [illegible] property in Billings is irrefutable.

The members of the [illegible] Board should remain cognizant of this small [illegible] megawatt coal-fired plant and the plant damage and air pollution it causes to the Billings area when considering the siting of an additional 1400 megawatts of coal-fired power plants in the prime agricultural lands of Southeast Montana. Furthermore, the Board members should remember that the State ambient air standards are not being exceeded in Billings, nor were they violated in the Mount Storm area of West Virginia and Maryland where the plantation owners have collected approximately one half million dollars in crop damage thus far from the large stationary air pollution sources.

I believe that Colstrip Units #3 and #4, if allowed to be sited in Colstrip, Montana, will during the majority of times meet both the State and Federal ambient air standards for all pollutants regulated. However, there is also no doubt in my mind, based upon my 12 years of study and experience in air pollution problems and litigation, that there will be times that strong winds, such as the 35 mph winds of Hurricane Agnes, which was the vector of the acute fumigation in Mount Storm, will take the Colstrip plumes of #1 and #2, or #1 through #4, down to the ground and cause acute fumigation damage to vegetation for 20 to 30 miles from Colstrip. During the majority of times when the State and Federal standards are met there will be slow insidious plant damage for a minimum of a 50 mile radius of Colstrip. To allow the siting of Colstrip Units #3 and #4 at Colstrip, Montana, based upon the fact that they will meet State and Federal ambient air standards, is ludicrous. The Board members need only look at the Montana Department of Health and Environmental Sciences air monitoring data and our plant damage data from Columbia Falls, Anaconda, Missoula, East Helena, Ramsay, and Billings, Montana, to know that there is absolutely no proof whatsoever that our State or Federal ambient air standards protect our citizens' property.

As previously stated, the support data for the testimony in this Section II are in the Exhibits.

SECTION III: ENVIRONMENTAL STUDIES LABORATORY STUDY DESIGN, STUDY PLOTS, AND BASELINE DATA GATHERING

This section is presented primarily to acquaint the DNRC Board members with how and where we have performed our various studies in the Colstrip area of Montana during the last four years.

Study Sites

Our original permanent study sites were established for our contracted DNRC study in 1973. Using the meteorological studies of Dr. Arlan Super, then Montana State University meteorologist, which he completed for the Montana Power Company, we established eight radii from Colstrip which radiated out 40 to 80 miles, depending on the dominant prevailing winds during the different seasons of the year. The longest of our study radii (80 miles) is to the southeast of Colstrip, since this is where the majority of Colstrip pollutants will travel during the growing season each year. At 5, 10, 20, 40, and sometimes 80 miles along each radii, permanent sites were established which were usually on State or Federal leased lands. Most of the 35 sites located along these eight radii were ponderosa-Rhus-bluebunch wheatgrass plots which were located on elevated terrain. At these sites, we collected five to eight species of plants at least two to three times per year for sulfur and fluoride analyses. All data from these sites were reported to Dr. Albert Tsao in our August, 1974, report to the Department of Natural Resources and Conservation.

From 1974 to the present we have received $136,000 from the EPA/NERL Laboratory located at Corvallis, Oregon, to work in the Colstrip area. This study is a collaborative team study composed of personnel from five laboratories in the Western U.S.: EPA/NERL at Corvallis; Dr. Jack Taylor and Sharon Evermar at Montana State University at Bozeman; Jerry Dodd, et al., grassland biome study group at Colorado State University; Vernon Derr of the National Oceanic and Atmospheric Agency (NOAA) at Boulder, Colorado; and our EVST Laboratory here at the University of Montana. Collectively, these five teams have six permanent study plots: three on Red Kluver's land, two on Wally McRae's land, and one ZAP plot on Taylor Creek, approximately 8 miles from the Fort Howe's Ranger Station in the Custer National Forest. This ZAP Plot #1 (Zonal Air Pollution fumigation plot) is primarily what I would like to explain to the BNRC Board members concerning our EPA studies, since the data gathered from this fumigation plot will be used in the next section to explain the impacts of SO_2 upon the grassland biome.

The ZAP plot is a 25-acre exclosure composed of a grassland-forb-shrub ecosystem dominated by western wheatgrass (*Agropyron smithii*). On four one-acre plots within this exclosure, aluminum pipes (see Exhibit 226) which deliver SO_2 to three of these one-acre plots at three different concentrations were built during the winter and spring of 1975. At one of the one-acre plots, SO_2 is delivered to the vegetation via the pipes so that the level of SO_2 on that particular plot is 10 pphm (.10 ppm) as monitored at a one-foot level above the ground by two to four SO_2 dynamic monitoring stations on each one-acre plot. This 10 pphm SO_2 concentration is five times less than the Federal 3-hour ambient air standard for SO_2 and five times greater than Montana's annual SO_2 standard (.02 ppm). At the other two one acre plots SO_2 is delivered at 5 pphm (.05 ppm) and 2 pphm (.02 ppm) respectively. The latter 2 pphm, as previously stated, is the annual SO_2 ambient air standard for the State of Montana. Over the fourth one-acre plot the aluminum pipes deliver air without any SO_2 and this is the control plot.

The ZAP site started operating on May 28, 1975, and continued to deliver (with only a few interruptions) the various SO_2 concentrations to the three one-acre plots 24 hours per day until September 28, 1975, when the study was completed. Personnel from the various laboratories (excluding NOAA) carried out various studies on the vegetation from each of the four one-acre plots during the fumigation period. This ZAP study is absolutely unique in the history of air pollution studies in that this has never been done before on such a large scale, and no one prior to this study had fumigated in situ these indiginous grasses, forbs, and shrubs to determine their susceptibility to SO_2.

The last two studies in the Colstrip area which we at the Environmental Studies Laboratory are participating in are (1) an ERDA-sponsored study with personnel from the University of Iowa Reactor Laboratory at Ames; the Battelle Pacific Northwest Laboratory at Richland, Washington; and Frank Munshower of Montana State University of Bozeman; and (2) a U.S. Forest Service/SEAM-sponsored study with Clint Carlson, Pathologist of U.S. Forest Service, Region I. The ERDA studies have allowed us to perform baseline trace metal (32 elements) analyses and gather data of the ambient air, terrestrial and aquatic plants, rodents, dry and wet deposition, and biomass production at several Colstrip sites which will be impacted by the emissions of Colstrip Units #1 and #2. The U.S. Forest Service/SEAM sponsored study has allowed us and Carlson to gather over 35,000 measured growth and chemical parameters from

176 ponderosa pine trees located, collectively, at 17 study sites prior to these trees being impacted by the emissions of Colstrip Unit #1. During the period of June, 1975, to November, 1975, personnel of this Laboratory and the U.S. Forest Service carried out detailed measurements on 366,080 ponderosa pine needles collected from 61,952 internodes, primarily because we believe this species will be the first to demonstrate a decline in growth from the emissions of Colstrip Units #1 and #2. Evidence of the type of damage that will occur to ponderosa pines is covered in Section V of this testimony to the BNRC Board members.

SECTION IV: BIOLOGICAL AND PHYSICAL IMPACT OF SO_2 UPON THE GRASSLAND BIOME OF THE COLSTRIP AREA

On October 16, [illegible], an experienced NASA aerial photographer out of Denver, Colorado, at the request of personnel at the EPA/NERL Laboratory, Corvallis, Oregon, took colored photographs of our EPA ZAP plots from a height of 25,000 ft. (7600 meters) with a 6" lens and 9" x 9" format. One of these colored photographs (only two copies of the colored photograph are presented in my testimony, the other eight copies of my testimony have black and white copies of this original color photograph) is presented here in this Section so that Board members can see the dramatic differences between foliage fumigated at the three SO_2 concentrations on the ZAP sites. It should be noted that this aerial photo was taken after fall greenup at Taylor Creek which occurs when adequate rainfall occurs in a "semi-arid" area, and that is the reason for the very observable differences between the three different SO_2 concentration plots, the control plot, and the surrounding "greenup" area. One also notes on the color aerial photograph the apparent drift patterns of the SO_2 from each of the fumigated plots. See Exhibit 227.

Special notice should be taken of the different SO_2 application plots and the control plot which is on the left middle portion of the picture, next to the main Taylor Creek Road, when considering the sulfur levels we found in vegetation from the plots on June 28 and again on September 28, where vegetation samples of the same species of grasses and forbs were taken from each of the different SO_2 concentration plots (10 pphm = .10 ppm, 5 pphm = .05 ppm, 2 pphm = .02 ppm, and 00 pphm = .00 ppm) for sulfur analyses.

The results of these analyses are presented here on two bar graphs, Exhibits 228 and 229, one bar graph representing the June sulfur accumulation, and the second the September sulfur accumulation. Exhibit 228 demonstrates that after continuous SO_2 fumigation for 30 days with .02 ppm (2 pphm)(the Montana State annual standard for SO_2), the sulfur accumulation had significantly increased in all species of plants analyzed from the .02 ppm plot except for Japanese brome grass. Of course the vegetation from the other SO_2 concentration plots contained, even after only 30 days, extremely high levels of sulfur in comparison to that found in the control plot (black bar on graph is sulfur levels in control plant species).

In Exhibit 230 is a nine page write-up on sulfur translocation and metabolism in plant species which includes the metabolism of sulfur dioxide and the toxic effects resulting from SO_2 fumigation, for those Board members interested in what the majority of plant scientists believe is the action of this essential element and its damaging effect when the plant gets too much of it from the atmosphere.

In Exhibit 229 is presented a bar graph which depicts the sulfur accumulation in plant species from each of the ZAP fumigation plots after four months (May 28 to September 28) of continuous fumigation at the three different SO_2 concentrations. One notes that in the majority of cases the sulfur accumulation in plant species fumigated at the Montana annual SO_2 standard of 2 pphm (.02 ppm) is approximately twice that of the same plant species from the control plot. This is an important point since the amount of sulfur which accumulates in plant tissues when fumigated at concentrations equal to our annual state standard of SO_2 (.02 ppm) is greater than the amount of sulfur which accumulates in plants in the Billings area where the Corette coal-fired power plant and the oil refineries pollute the ecosystem.

The third graph (Exhibit 231) concerning the sulfur accumulation in plant species from the ZAP site is presented for the DNRC Board members' inspection and study. This demonstrates the difference in sulfur accumulation between two different species when fumigated at equal SO_2 concentrations on the ZAP sites.

The interrupted line on this graph (Exhibit 231) represents the sulfur accumulation of western wheatgrass (*Agropyron smithii*), considered to be one of our most dominant and important forage species in the Colstrip area. One notes that in June the western wheatgrass from the control plot had 1200 ppm of sulfur and 800 to 900 in September. When fumigated for four months at the three different SO_2 concentrations, there is a continuous increase in sulfur accumulation regardless of the SO_2 fumigation level. The same pattern of continuously increased sulfur accumulation is also seen to occur in Japanese brome (*Bromus japanicus*). What makes this continuous sulfur accumulation extremely important is that the fumigation commenced on May 28 when the fastest and most succulent growth of these two species of plants was already completed and thus (even according to Dr. Peter Edmonds of the Westinghouse Corporation) past the period of time when these two grass species would have been most susceptible to fumigation damage. It is unfortunate that the SO_2 ZAP fumigation was started so late in our 1975 studies, but this will be rectified during our upcoming 1976 fumigations on the ZAP #1 site and our new ZAP #2 site, where we will start the SO_2 fumigation experiments at the end of March when these early cool weather grass species begin to grow.

Doctors Jerry Dodd and Bill Lauenroth, and others of Fort Collins, Colorado, who carried out biomass studies on the ZAP #1 site during this last year could not demonstrate a loss of biomass between the three different SO_2 fumigation plots from the control plots. This is believed to be due to three problems: First, as previously mentioned, the fumigation was started two months after the cool season grass species had begun growing and had reached at least one-third of their natural growth. Second, the initial first year impact of the SO_2 fumigation is better measured during the growing season of the following year on many species of plants. And third, the methodology used by the grassland biome study group during this last growing season does not always allow for determining a loss of biomass unless the biomass loss of western wheatgrass is 30 to 40 percent from the control. This means to me that up to 29 percent of our Montana western wheatgrass ecosystem could be destroyed prior to determining if Colstrip Units #1 or #2, or Units #1 through #4, are causing damage to Red Kluver's or Wally McRae's pasture and rangelands or all the rest of the ranchers in the Colstrip area. This lack of being able to evaluate loss of biomass at the 5 to 10 percent level of damage is expected to be rectified by the EPA sponsored researchers this coming growing season. Even though no change in biomass was determined during this last study season, I would urge the DNRC Board members to look again at the NASA photograph taken at 25,000 ft. elevation, and to think of the ecological consequences of the potential chronic SO_2 fumigation in the Colstrip area at the Montana annual standard of .02 ppm.

There are three points which I consider necessary to briefly testify to here in this Section which concern the soils (pH and moisture) and phenology (growth patterns) of the plants in the Colstrip area to be impacted by the pollutants of Colstrip Units #1 and #2. Dr. Peter Edmond (Westinghouse Corporation biologist) testified to the BNRC board members on the alkaline (non-acidic) soils of the Colstrip area and the semi-arid nature of the area which would (according to Edmonds) account for the potential resisteance of plant species growing there in contrast to plant species growing in a wetter and non-arid region.

The pH of soil samples from Colstrip study sites of Dr. Frank Munshower of Montana State University demonstrates that indeed there are soil samples which can be considered alkaline (pH >8.4); however, these soil samples are not usually in the upper 10 cm of the soil profile, but deeper. In fact, Munshower's studies reveal that the upper 1 to 2 cm soils are approximately neutral (pH 7.0) and that the deeper the soil samples are taken, the more alkaline is the soil. Furthermore, his studies demonstrate that at 30 cm one finds abundant carbonates which probably slow water percolation and allows for adequate water availability during the growing season of the plant species in the Colstrip area. Thus one can consider these plant species to be similar or even identical in susceptibility (depending on environmental conditions) to SO_2 as plants growing in "wet and lush" areas. Three graphs have been prepared for this portion of my testimony; one which demonstrates soil pH as a function of soil depth, another which demonstrates rainfall and humidity in the Colstrip area during the growing season of the cool season grasses, and the last which demonstrates the phenology of a few of the cool season grasses. See Exhibits 232-A through E.

From the data on two of these graphs, it is easy to ascertain that during the growing season of these rangeland grass species there is adequate humidity and soil water to have lush plant growth during three months when the winds will bring the pollutants to the rangelands of the area from Colstrip Units #1 and #2. Phillip Tourangeau will discuss these three aspects further when he testifies to the DNRC Board members on the phenomenon of acid rains.

SECTION V: BIOLOGICAL AND PHYSICAL IMPACT OF COAL-FIRED POWER PLANT EMISSIONS UPON THE CONIFEROUS TREES OF THE COLSTRIP AREA, INCLUDING THE CUSTER NATIONAL FOREST AND THE NORTHERN CHEYENNE RESERVATION

As previously mentioned and supported in the data presented on the ponderosa pine damage occurring on our GB-1 site, ponderosa pine is an extremely susceptible plant species to SO_2 fumigation and acidic solutions. Unfortunately, ponderosa pine is also extremely susceptible to hydrogen fluoride as reported by us and Clint Carlson of the U.S. Forest Service in our separate studies of damage in the Columbia Falls area of Montana around the Anaconda Aluminum plant. Even more unfortunate for the ponderosa pines in the Colstrip area and the people who depend on this species for their livelihood, is the fact that ponderosa pine is also extremely susceptible to ozone fumigation. This is evidenced and attested to by the studies of Miller (U.S. Forest Service) in the San Bernardino Mountains on the east side of the Los Angeles basin. From our studies of air pollution damage to conifers in various areas of the U.S. and Canada, it is obvious that only three other species of conifers in these areas have been demonstrated to manifest more foliar damage to SO_2, HF, NO_x, and O_3 fumigation in the field than has ponderosa pine. They are Eastern and Western white pines (Pinus strobus and Pinus monticola) and Scotch pine (Pinus sylvestrus). Outside of foliose lichens growing on the ponderosa pine in the Colstrip area, we consider this conifer species as the most sensitive biological indicator of phytotoxic gases, acidic rains, and acidic solutions growing in our study area. As reported in our 1974 DNRC report to

Dr. Albert Tsao, basal needle necrosis caused by acidic rain was occurring to ponderosa pine foliage prior to Colstrip Unit #1 going on line. Also we have performed histologic studies on needle tip necrosis from some of our Colstrip sites (BNW-3, SE-5, NE-4) caused by SO_2 and/or HF fumigation even when only slightly detectable concentrations of these gases have been reported by the state and Federal air monitoring personnel in any of their numerous reports.

To understand how this damage is occurring when only slightly detectable concentrations (far below State standards) are present in the ambient air, one has to dissect the needles into the same five portions as we did for the damaged Billings ponderosa pine foliage from GB-1 and GB-2 sites (refer to data in Exhibit 226).

In Exhibits 233-A through C, the reader will find the results of over 150 sulfur and flucride analyses on portions of needles collected from the immediate vicinity of Colstrip prior to the burning of coal in Unit #1. As can be seen from the data on these three tables, elevated fluoride levels are found on the fascicular sheath tissues of needles for each year's needle growth from each of the three sites. Also at Colstrip sites H-1 and H-2, elevated fluoride and/or sulfur levels occur in the needle tip portions for certain years over that found in the middle portion of the needle. If one compares the sulfur and fluoride data on these three tables with similar type data from analyses of dissected needle portions from (1) our SE-5 site (located 10 miles from an oil field in Wyoming where they burn off sulfurous gases), shown in Exhibit 233-D, (2) our GB-2 site at Billings Heights near Billings, Montana, shown in Exhibit 233-E, and (3) our Western Montana control site (Potomac Valley, 3 miles up Twin Creek Road) shown in Exhibit 233-F, then it becomes obvious to the reader that indeed the ponderosa pine in the immediate vicinity of Colstrip has excessive levels of fluoride and sulfur. One can also see that the ponderosa pine is [illegible] an indicator for the presence of phytotoxic gases and particulate pollution as any dynamic or static monitoring system being utilized in the Colstrip area.

The question arises: Where did the excess sulfur and fluoride come from in the Colstrip area (i.e., at H-1, H-2, and H-3 sites as shown in Exhibits 233-A through C) which caused the needle tip necrosis and basal tissue necrosis to the ponderosa pine? When we first discovered the fluoride-and sulfur-caused tissue pathology in the tips and bases of necrotic pine needles at the Colstrip sites and then compared the amount of sulfur and fluoride released from the burning of approximately 250 to 350 tons of coal per year collectively in the 57 Colstrip homes burning coal (personal communication from Frank Munshower, 1975), we believed that the 15 to 20+ pounds of fluoride released and the 2 to 3 tons of sulfur (4 to 6 tons SO_2) released into the Colstrip atmosphere was rather low. To arrive at the emissions from the Colstrip homes we used the following computations:

$$\frac{250 \text{ tons coal}}{\text{year}} \times \frac{2000 \text{ lbs coal}}{\text{tons of coal}} \times \frac{35 \text{ lbs } F^-}{1{,}000{,}000 \text{ lbs coal}} = \frac{17.5 \text{ lbs } F^-}{\text{year}}$$

$$\frac{350 \text{ tons coal}}{\text{year}} \times \frac{2000 \text{ lbs coal}}{\text{tons of coal}} \times \frac{35 \text{ lbs } F^-}{1{,}000{,}000 \text{ lbs coal}} = \frac{24.5 \text{ lbs } F^-}{\text{year}}$$

(Assume .7 percent sulfur and 35 ppm fluoride in coal)

However, when comparing ambient air fluoride concentrations in the Colstrip area (Department of Health and Environmental Science data from Na formate analysis) with those found in Glacier Park, where we have documented fluoride-caused conifer damage and excessive fluoride accumulation in animals from 1970 to 1975 in our studies for EPA and/or Department of Interior, we found that Colstrip ambient air is sometimes higher in fluoride levels than Glacier Park.

If one compares the yearly emissions of SO_2 and fluoride from the 57 homes in Colstrip which together burned approximately 250-350 tons of coal per year with the emissions of what will come out of Colstrip Units #1 and #2 or Units #1 through #4, according to Montana Board of Health findings of fact as written by C. W. Leaphart, then one understands why all scientific evidence points to serious ponderosa pine damage throughout the Colstrip area in the near future. In Exhibit 234 is presented the yearly emissions of six compounds or elements (including SO_2 and fluoride) which will be emitted by Colstrip Units #1 or #2, Units #3 or #4, or Units #1 through #4, if or when the BNRC Board approves the siting of these last two units at Colstrip, Montana.

These data demonstrate that 350 to 466 times more fluoride and over 1800 times more SO_2 is going to be released from Colstrip Unit #1 alone than is coming from the coal-burning homes at Colstrip which are now causing the tissue damage to ponderosa pine. The fact that the emissions will be released from a 500+ ft. stack simply means that more trees throughout the area will be damaged. If Colstrip Units #1 through #4 go on line then the annual load of atmospheric fluoride and sulfur will increase over 1900 times for fluoride, 11,500 times for SO_2, plus 67,196 tons of NO_x, all of which will be released from tall stacks. This simply means that the impact on the coniferous forest of Southeastern Montana is going to be severe. The damage will be severe, not because the standards for these gases and particulates will be violated, but because the phytotoxic emissions will be there. And they will be there on the lush and fast growing Northern Cheyenne forests and the slower but healthy growing forests of the Custer National Forest 15 to 60 miles from Colstrip, Montana.

If the forests of Southeastern Montana were composed of Douglas fir and spruce species rather than ponderosa pine, the impact of the emissions of Colstrip would be substantially less severe than will be on the ponderosa pine forests when Units #1 and #2 are in full operation. The only way to stop the pending damage to the Northern Cheyenne and Custer National Forests from the emissions of Colstrip Units #1 and #2 is to reduce the height of their stacks to 50 or 100 feet. After reducing the height of the stacks, the only way to reduce the damage to the ponderosa pine savannahs in the immediate vicinity of Colstrip as well as those ponderosa pines planted on the reclamation plots is to have Montana Power Co. install the very best abatement equipment on the market today.

SECTION VI: ACIDIC PRECIPITATION AND ITS EFFECT UPON THE ECOSYSTEMS OF THE COLSTRIP AREA AND OTHER AREAS OF THE FORT UNION BASIN

The majority of information on the chemistry of precipitation in polluted areas will be presented by my research associate, Phillip Tourangeau, in his own testimony. The information I will present here in this Section VI relates briefly to the acid rain damage to vegetation in several areas: (1) Mount Storm, (2) several localities in Montana, (3) greenhouse studies using acid solutions on emerging pine needles, and (4) greenhouse studies of synergism between the herbicides 2-4D and 2-4-5T and acid solutions in causing the short-long needle syndrome. I encourage the DNRC Board members to read the 38-page paper "Conifer Tree Damage in the Vicinity of Large Stationary Sources of Phytotoxic Gases" (Exhibit 224-B) which Phillip Tourangeau and I presented at the annual Air Pollution Control Association (APCA) meeting in Boston, Massachusetts, in 1975. This article covers most of the data we presented in Federal Court in Alexandria, Virginia, during 1973, in the case of Stacey vs. Virginia Electric Power Co. (VEPCO). As a result Stacey was awarded $25,000 for air pollution damage to his Christmas trees which was upheld in the Circuit Court of Appeals. Also the data in this article is what I testified to in the Federal Court in Baltimore, Maryland, in the spring of 1974 in Steyer, et al. vs. Monongahela and Alleghany Power Companies. This testimony was not refuted by any scientist or witness appearing for the power companies. Complete copies of my testimony, depositions, and EPA progress reports during the entire Mount Storm studies and litigation are available here at the EVST Laboratory to any member of the BNRC Board who wishes to read the voluminous materials acquired during this five-year study period.

The reason I bring up the above Mount Storm issue in my testimony here is that Dr. Peter Edmonds of Westinghouse Corporation, when testifying for the Montana Power Co. (pp 12-14) claims that the abnormal disease syndromes (short-long needle syndrome and destroyed dwarf shoot buds) occurring on the Christmas trees of the Mount Storm area were caused by mites or "other insects" (sic). First and foremost, mites are not insects; and second, Dr. F. A. Wood, Dr. M. Farrier, Dr. J. R. Baker while they worked on the "mite theory" never claimed that a mite caused the damage. The depositions of these three individuals on their studies for the Alleghany and Monongahela Power Companies are here in the EVST Laboratory and available for the inspection of Board members. It should also be noted concerning the studies of Dr. Wood and Dr. Baker, along with Dr. Pennypacker (who also worked with Wood for the power companies) that, under oath in a deposition taken from me here in Missoula by five lawyers representing the Alleghany and Monongahela Power Companies, the pulp and paper mill, and the insurance companies who had insured these three polluting industries, I testified on how Doctors Wood and Pennypacker had obtained the abnormal disease syndrome on Scotch and white pines in their experiments by cheating and lying. None of the entomologists mentioned above, nor Doctors Wood or Pennypacker, were called to the Federal Court trial in Baltimore by the lawyers of the power companies to testify against Steyer, et al. in their claims of Christmas tree damage. Nor was there any attempt by company biologists to present data or to refute my testimony on acid rain damage to the Christmas tree plantations. The entomologists, pathologists, etc., simply didn't show--after having received over $1/4 million from the three utility companies to perform "research" to prove that a biotic agent caused the damage rather than the very acid rains in the area.

The acid rain phenomenon has been studied since the early part of this century, but intensive studies were not initiated until the early 1950's in Europe and the late 1960's in the United States. One of the early studies was done by Cohen and Ruston where different plots of timothy grass were treated with sulfuric acid solution in a pH range of 2.2 to 3.7. Their experiment lasted for a period of three years and when concluded demonstrated that the effect of the acid ranged from death of the grass species (lowest pH) to a substantial decrease in productivity (highest pH). Studies during the last twenty years have demonstrated that acidic rains can cause death to aquatic plants and animals, change the microbial activity within soils, reduce the available nutrients in soils, increase the acidity of forest soils, and reduce the productivity of coniferous and deciduous forests.

Controlled acid mist and inoculation studies have revealed that acidic solutions cause a reduction in carbohydrates in bean plants, loss of chlorophyll in mosses, and overall loss of biomass.

All higher organisms undergo a period of development where the embryonic tissue that forms after fertilization of an egg becomes specialized for specific functions. In animals, after cells differentiate from the embryonic tissues, the latter tissues cease to function early in the life of the individual and growth or increase of size occurs until the animal reaches maturity. Plants on the other hand retain portions of embryonic tissue throughout their lives within the meristematic areas (i.e., leaf or flower buds). It is this meristematic tissue which is particularly vulnerable to acid rains when it is not well protected and/or if the meristematic tissue remains meristematic for longer than normal periods.

Young emerging pine needles have meristematic areas at their bases where they are attached to the stem, and this meristematic tissue is protected by the fascicular sheath which I have discussed previously. This basal meristematic area is called an intercallary meristem, which in many ways is similar to the intercallary meristem of grasses. When you members of the BNRC Board cut your grass lawns during the summer, the reason the lawn continues to grow is that you have not cut off or destroyed this embryonic or meristematic tissue located at the base of the grass, and thus you continue to have growing grass throughout the warm seasons of the year.

One of the major problems that we had in our past acid studies on coniferous foliage was to determine why there was more prevalent acid rain caused damage (i.e., short-long needle syndrome) in specific Mount Storm plantations than in others, and also why in other areas of the U.S. (such as 40 miles from the Anaconda Copper smelter, Sorosis park near the Martin Marietta Aluminum plant in The Dalles, Oregon, and at the golf course near the Intalco Aluminum plant at Ferndale, Washington) there were high incidences of the disease.

The answer to this problem is that herbicides (2-4D or 2-4-5T) were utilized near or at the vicinity where the high prevalence of the diseased trees were located. Under controlled conditions in the University of Montana Botany Greenhouse during the last year, we have carried out extensive studies on the effects of very dilute herbicide solutions (2-4D and 2-4-5T, 1/10 to 1/100 normal application concentrations) and very weak concentrations of a strong acid (H_2SO_4 at pH of 3.5 to 5.5). Histological studies of the greenhouse herbicide and acid treated pine needles were carried out which were identical to those performed on diseased pine needles from Colstrip, Billings, Anaconda, Mount Storm, and Ferndale, Washington, etc. These histological studies revealed that the herbicides cause the meristematic (embryonic) tissues of the young pine needles to remain meristematic for a period of 2 to 3 months longer than normal. This means that the thin walled meristematic cells do not differentiate and mature at a normal rate, and thus are susceptible to the weak concentration of acid for a much longer period of time.

Even without the presence of the herbicides in the environment of the ponderosa pine, their fascicular sheaths which protect their embryonic (meristematic) tissues is their Achilles' Heel. With the presence of herbicides such as 2-4D or 2-4-5T the Achilles' Heel turns into a Waterloo. Now for the third time in the University of Montana Botany Greenhouse we are performing controlled inoculation studies with weak concentrations of H_2SO_4 (pH 3.5 to 5.5) and herbicides (1/100 to 1/500 normal application concentrations) on emerging needles and candles of Scotch, ponderosa, and white pine. The members of the Board, Counsel for the Montana Power Company, or anyone else are invited to visit and inspect our studies.

Other studies by us on the physical properties of fascicular sheaths of ponderosa pine and on H_2SO_4 acid solutions at different pH's when the solutions are evaporated down to smaller and smaller volumes have been carried out during the last two years. For instance, studies on light transmission of excised ponderosa pine sheaths show that as the wavelength of incident light increases, the amount of light absorbed by the fascicular sheaths decreases and more light passes through them. In the infra-red, very little light is absorbed by the sheaths, most being transmitted. Any substance lodged between the sheath and the needle which will absorb infra-red radiation without re-radiation or which is opaque to infra-red would be expected to increase in temperature.

Studies on low concentration of strong acid (H_2SO_4) have been demonstrated to become more concentrated during the evaporation of H_2O off the solution and thus more and more acidic. Therefore, it really doesn't matter that the acidic rains which will occur in the Colstrip area from the conversion of SO_2 and NO_x to H_2SO_4 and HNO_3, respectively, will not have a pH value of 3.5 or even 4.5 to cause immediate (10 to 30 days) burnout of the meristematic or thin-walled basal tissues of ponderosa pine needles. The fact that the acids are there, in even weak concentrations (pH 4.5 to 5.5) and become lodged in the fascicular sheaths, means that during evaporation in this semi-arid region the acids in the fascicular sheaths will become more and more acidic and will cause death to the immature and mature cells of this Achilles' Heel of the pines.

We at the University of Montana EVST Laboratory have spent the last five years carrying out numerous physical, chemical, and histological studies on the Achilles' Heel of pine species, and these studies leave no doubt whatsoever that when SO_2, NO_x, and HF are released as gaseous emissions or in soluble sulfur and fluoride particulate form into the atmosphere of Colstrip, Montana, the pine trees throughout the entire area will be impacted, damaged, and have reduced growth because of the ensuing tissue necrosis. While we do not at this time have any scientific data on the measured effects of low (4.5 to 5.5 pH) concentrations of the weak and strong acids (HF.H_2O, and H_2SO_4, HNO_3, respectively) on the grassland forbs, shrubs, and grasses of the Colstrip area, we believe that the effects will not be beneficial.

SECTION VII: POTENTIAL DAMAGE TO INDIGENOUS AND DOMESTIC ANIMALS BY GASEOUS AND PARTICULATE EMISSIONS OF COAL-FIRED POWER PLANTS

During the last ten years we have collected, by trapping, shooting, and acquisition from veterinarians, farmers, ranchers, and fish and game personnel, the bone and/or soft tissues of over 3000 animals for various types of chemical and physical analyses. The data obtained from the analyses of approximately 1000 of these animals have been reported in Federal and state agency reports or in the scientific literature.

In the area of Colstrip, Montana, during the last three years we have trapped and/or acquired from the Montana Fish and Game biologists the bones and soft tissues of over 1200 animals and game birds to determine the baseline levels of fluoride and/or trace metals in these animals prior to Colstrip Unit #1 going on line. While the fluoride analyses of 85 per cent of these Colstrip area animal collections have been completed, the trace metal analyses have not. Thus we will present here only a condensation of some of the fluoride data and attempt to relate the accumulation of fluoride to other trace elements.

The average baseline levels of fluorides in the bone tissues of indigenous Colstrip area mammals (mule and whitetail deer, antelope, and several species of rodents) as well as game birds (sage and sharptail grouse) are as low as any control area animals we have previously worked with (less than 350 ppm). A table which contains the fluoride levels of 150 deer mice (Peromyscus maniculatus) collected within two miles of the town of Colstrip is presented in Exhibit 235.

As the reader can ascertain from the fluoride concentrations found in the femur bones (upper large leg bones) the amount of fluoride accumulation is slightly different between males and females of this species. Also in Exhibit 235 is data which depicts the fluoride levels of 29 deer mice collected from the Billings area of Montana. If one compares the average fluoride levels found in the femur bones of the 29 deer mice from the Billings area with that of either the average levels found in the femur bones of the 60 male or 50 female deer mice femur bones from the six Colstrip sites, one notes that there is a 5.7 and a 4.9 increase, respectively, of fluoride accumulation in the Billings deer mice. This same trend holds true if one compares either the single lowest or highest concentration of fluorides found in deer mice femurs from the Billings area with those collected from the immediate vicinity (2 miles) of Colstrip.

One of the points that Dr. Peter Edmonds (Westinghouse Corporation Biologist) testified to for the Montana Power Company (Page 36 of his testimony) is the following: "Most animals are better able to tolerate fluorides in greater quantities than cattle. With carnivorous animals, fluoride transfer through the food chain is not a problem. Fluoride is largely accumulated in the bones and teeth of the animals and unless these parts are ingested a significant transfer of fluoride is not possible." First, Edmonds has no scientific basis at all that "most animals" have ever been analyzed for fluoride levels. Second, of those indigenous animals that have been collected by us (and reported in various reports) in areas where cattle, sheep, or horses have been damaged by fluoride ingestion, the wild indigenous animals usually have higher fluoride levels than the domestic animals which were tested. It should further be noted that the domestic animal bones we tested from these areas (Ferndale, Washington; Hall, Garrison, and Columbia Falls, Montana) were sacrifice animals, and therefore the most fluoride damaged animals of the owner. The indigenous animals which we collected by trapping or shooting were still able to move around and that is why we were able to collect them. Edmond's statement on carnivorous animals' eating habits is also misleading and ridiculous. There is a possibility that Dr. Peter Edmonds has never had the opportunity of raising a domestic dog or cat and thus hasn't observed their eating habits. If he had, then he would know, without going to the scientific literature, that they are omnivorous besides being carnivorous in their eating habits. Wild, indigenous, carnivorous mammal species in the Colstrip area are also omnivorous and will consume entire bodies of mice, "bugs", seeds, fruits, and a rancher's calf, lamb, and housecat if given the opportunity.

However, it is not my task nor intent to spend my time and yours berating Dr. Edmonds' biological talent; only to remind the Board members that Dr. Edmonds' testimony on fluorides and trace metal contamination and animal ingestion in the vicinity of coal-fired power plants is based on his subjective thinking and not on his or any other investigations.

At this point in time, unfortunately, no one knows what the rate of trace metal or fluoride uptake in the Colstrip vegetation, indigenous animals, or domestic animals will be from Unit #1, let alone Units #1 through #4. We have been unable to find a single scientific or popular article which relates directly to this subject, and therefore we are relying on our studies in East Helena (trace metal contamination of vegetation and animals) and our fluoride studies in numerous areas, to predict potential problems.

In previous sections I believe I have demonstrated that fluoride contamination of vegetation will occur in the vicinity of Colstrip as Units #1 and #2 emit this trace element into the atmosphere. Trace elements such as arsenic, lead, mercury, and selenium, will also be emitted into the atmosphere and will contaminate the forage. Because it is our belief (from earlier studies we have previously discussed) that the indigenous animals will accumulate most of these trace elements, except for possibly selenium, we are depending on our post-baseline data and future collections of animal tissues from the Colstrip area, and trace element analyses, as an early warning system for the potential contamination of the number one agricultural product of the Colstrip area: beef cattle.

We need another two years of indigenous animal collection and analysis in the Colstrip area before we can predict with scientific certainty how and when domestic and indigenous animals will be damaged by the trace element emissions of coal-fired power plants. Therefore a cessation of any further siting of coal-fired power plants in one of the nation's most prime cattle rangeland and game animal habitats is deemed imperative.

SECTION VIII: SUMMARY AND CONCLUSIONS
OF SITING THE PROPOSED COLSTRIP UNITS #3 AND #4
AT COLSTRIP, MONTANA

I believe that the data and explanations which I have presented in the first seven sections of my testimony should adequately demonstrate to those DNRC Board members who read these sections that we cannot explain all of the damaging air pollution consequences of siting Colstrip Units #3 and #4 in a prime agricultural and timber area of Montana. However, we have demonstrated and suggested enough damage to have you members consider the Montana Power Company siting proposal with more knowledgeable regard for the environmental impacts than did the members of the Montana Board of Health. All of you DNRC Board members have lived in Montana a considerable time and undoubtedly all of you remember the outstanding air pollution events which have occurred during the last 17 years. It is this pertinent history of the air pollution events from such industries as Hoerner Waldorf Pulp and Paper Mill (Missoula), ASARCO lead smelter (East Helena), Anaconda Aluminum Smelter (Columbia Falls), Stauffer Chemical (Ramsay), Corrette coal-fired power plant and oil refineries (Billings), which I would like to discuss for just a moment with you before considering Colstrip Units #3 and #4.

The Hoerner Waldorf Corporation sited their Kraft pulp and paper mill in the Missoula Valley in 1957, explaining via the local Chamber of Commerce that their proposed facility was the "most modern" unpolluting Kraft pulp and paper mill in the country, and that many people would benefit directly and indirectly from this industry. Most people of the Missoula Valley believed this oral and written verbiage and the plant was built as cheaply as possible as far as air pollution abatement equipment was concerned. They have polluted this Missoula Valley for the last 19 years, and did nothing to clean up their pulp and paper operation until the citizens of this valley raised $13,000 to bring a lawsuit in 1968 to abate this Hoerner Waldorf pollution. While it is important to give credit to the Hoerner Waldorf Corporation for their 1969 and current efforts to abate their and our air pollution problems, what they really did during the last 19 years was to eliminate any possibility of a competitive Kraft pulp and paper mill from locating in Western Montana, which is a prime pulp and paper timber growing area. They eliminated that competition unintentionally or intentionally by: (1) refusing to spend the money for available air pollution abatement technology in 1960, (2) by having contempt for the citizens of the Missoula Valley who, in turn, made it known to all citizens of the State that Kraft pulp and paper mills were bad news, and (3) because Hoerner Waldorf's lack of social responsibility made it impossible for the citizens of any town in Western Montana to willingly accept a new Kraft pulp and paper company in their community regardless of the benefits of increased employment.

The ASARCO lead smelter in East Helena, Montana, is an old smelter. It operated during its early years (from 1888) without benefit of air pollution equipment because there was no effective equipment on the market. However, since 1925 adequate and refined abatement equipment has been available and this company has refused, to this date, to install it. The Montana Department of Health and Environmental Sciences now requires that, by 1978, ASARCO abate its emissions by 75 percent. I bring up ASARCO and its management

(Mr. Stan Lane and Mr. Charles Barber) to you Board members because they are the prime examples of totally irresponsible citizens who, along with other Montana industrial spokesmen (including Montana Power Company), testified in the State Capital between 1964 and 1970 for the poor air pollution laws we now have. I enclose in Exhibit 236 a self explanatory letter sent by Stan Lane in 1968 to a former East Helena resident, Paul Bessler. No one should be surprised, in the not so distant future as Colstrip Unit #2 goes on line, that Montana Power Company personnel will be sending somewhat similar letters to Colstrip ranchers such as Red Kluver, Bailey Egan, Wally McRae, and the Northern Cheyenne Tribal Council. I enclose in Exhibit 237 a letter sent to me by Dr. Henry A. Schroeder, one of the nation's most eminent medical experts on trace metal poisoning of humans. The letter concerns the seriousness of trace metal poisoning in East Helena. In 1968 I requested help from Dr. Schroeder in determining if Mr. Charles Barber's lead smelter emissions were molesting the children of East Helena as seriously as were his smelter emissions harming children in El Paso, Texas, and Tacoma, Washington.

The Anaconda Aluminum plant was built in Columbia Falls because the Hungry Horse Dam was built on the South Fork of the Flathead River. The Company was allowed to buy all the "surplus electrical energy" from this dam, which is more electricity than all the residents of Western Montana use, for ½ to 1 mill per kilowatt. The selection of the siting acreage for the aluminum plant suggested by the design engineer was that a two-pot line operation could be built without too serious an environmental impact to the area. However, with the increased market demand for aluminum, more employment, more throw-away aluminum food and drink containers and cars, the two-pot line aluminum plant was increased two and a half times to five-pot lines. Air pollution studies on the biological consequences of the fluoride impact to Federal and private lands were carried out from 1968 to present, and approximately one fourth to one half million dollars have been spent to date by Federal and State agencies to document this damage.

Neither the EPA, the U.S. Forest Service, nor the U.S. Park Service (Glacier National Park, Department of Interior) have carried out a lawsuit against this intentionally polluting industry after it was well documented that serious fluoride damage was occurring to Federal lands and a National Park. This fact should give the DNRC Board members some insight into the amount and caliber of litigation assistance the ranchers of Colstrip and the Northern Cheyenne Tribal Council will receive from these agencies when their lands are damaged by the emissions of Colstrip #1 and #2.

For the Board members to accurately understand the amount of help the ranchers of Southeastern Montana can expect to receive from our State Air Quality Bureau of the Department of Health and Environmental Sciences when ranchlands are impacted and damaged by the emissions of Colstrip #1 and #2, I enclose Exhibit 238: the chronology of air pollution events in Ramsay, Montana (Stauffer Chemical Company) during the last 20 years. Also enclosed as Exhibit 239 is a 1975-76 study on fluoride pollution at Ramsay, Montana, carried out by students and personnel of the University of Montana Environmental Studies Graduate Program which documents the serious fluoride pollution problem.

In earlier portions of my testimony I have discussed the seriousness of air pollution problems in Billings, Montana, which obviously, from the lack of Billings citizens' complaints, demonstrates how the people have grown accustomed to it. However, it is not the lack of citizens' complaints that should interest the DNRC Board members as much as the total lack of progressive air pollution abatement programs for the refineries and the Corrette power plant during the last ten years by their respective managements. It is inconceivable to me, and I hope to the DNRC Board members, that when Montana Power personnel claim they will make Colstrip Units #1 through #4 a 2100 megawatt, non-polluting, non-damaging modern coal-fired power plant complex--and yet have allowed the 180 megawatt Corrette plant to pour into the atmosphere of Billings approximately half of the entire industrial pollution of that city--that they expect me or anyone else to believe their verbiage.

Unfortunately the short and brief history of air pollution problems in Montana which have occurred during the last 17 years is rather depressing, but the DNRC Board members must recognize how my feelings evolved from having performed studies in all of the above-mentioned areas to learn the subject of air pollution and its effect upon our environment. I accept the fact that this nation needs to build coal-fired power plants now and in the future for our energy needs and that some of these plants will have to be sited in Montana. I am not now nor have I ever been against responsible industrial growth here in Montana or anywhere else in this country, for without continuous but wise expansion there is no way to feed and house our ever increasing populations.

The siting of large coal-fired power plants (300 to 5000 megawatt) must be done with extreme care because it is believed by utility company management that it is not now feasible economically to abate damaging amounts of air pollutants from these large plants. It is technologically possible to abate these plants, but would increase the cost of electricity if abated so that we could no longer afford to waste it.

We can afford much less, however, to destroy or damage our agricultural base in this nation since ALL scientific evidence points to devastating food shortages throughout both the industrialized and non-industrialized nations of the world by 1985.

It is indeed unfortunate that Colstrip Units #1 and #2 were allowed by personnel of the Montana Department of Health to be built at Colstrip since these two units are, without any doubt, going to cause damage to the pine forests and grassland ecosystems of that area. To allow the building of Colstrip Units #3 and #4 in this agricultural area is even less intelligent than to allow Anaconda Aluminum to build ten more pot lines in Columbia Falls. Colstrip Units #3 and #4 should be located in a non-agricultural area of Montana and in an area where the least environmental impact will occur. As in my original 1974 report to the Department of Natural Resources and Conservation, I continue to believe that the proposed Colstrip Units #3 and #4 should be sited at Butte, Montana, and should be called Butte Units #1 and #2 or George O'Conner Units #1 and #2.

HEARINGS EXAMINER: Mr. Peterson, you may cross-examine.

MR. PETERSON: First of all, Mr. Davis, relative to some of the exhibits, I would at this time interpose objections to certain exhibits and then continue with the examination of Dr. Gordon and interpose the appropriate objections at the time we get the others, but at the outset, I would object to the introduction of Exhibit 236, on the grounds that it is irrelevant and immaterial, and to Exhibit 237, for the same reasons, and 238, for the same reasons, and 239 for the same reasons.

HEARINGS EXAMINER: Very well, I'll take that under advisement.

MR. SHENKER: I should speak to them then, rather than now?

HEARINGS EXAMINER: Yes, why don't we.

EXAMINATION OF DR. CLARENCE C. GORDON

Cross, by Applicants

By Mr. Peterson:

Q Dr. Gordon, when did you first become involved with the Colstrip project?

A In 1972.

Q Was that before the Board of Health, relative to Colstrip units 1 and 2?

A That is correct.

Q When did you first become involved with Colstrip units 3 and 4?

A I believe our contract with the DNR on Colstrip 3 and 4 was in 1973.

Q That would have been around July of 1973?

A I believe that is correct.

Q What did the contract specify as to what your association was going to be with the project?

A I don't have it here with me. I do have it in town, but I think in general, the contract says -- the contract came, actually, from a proposal that we submitted to the DNR. Our proposal, in general, said that we would collect baseline data throughout the Colstrip area, how we would collect that data, why we would collect that data, and that we would report this data to the Board, the Department of Natural Resources and Conservation, by such and such a date, and if we did not, we would pay, I think the contract said, a thousand dollars a day or a thousand dollars a week, or something like that.

Q With regard to the collection of the baseline data, did you make a recommendation to the Department of Natural Resources at that time as to the proposed area that you felt was necessary in which to collect this baseline data?

A Yes. As far as why we collected on our various radii, different distances-- is this what you're after?

Q That's right.

A We did give reasons for the areas of collection and some of the reasonings for setting up the sites where they were set up.

MR. PETERSON: What's our next number, Carl?

HEARINGS EXAMINER: Just a moment, and I will look -- 239.

Q I'm handing you, Dr. Gordon, what has been marked as Applicants' Exhibit 239, and I'll ask you if you can identify this document as being the proposed sampling site and approximate area that you suggested be made to the Department of Natural Resources?

A Yes, this Exhibit 239, Applicants' Exhibit 239, is a xeroxed copy of the general outline of where we have our radii, and how far they extended from Colstrip, Montana.

Q And was that study area acceptable to the Department of Natural Resources?

A I believe it was.

Q Did you, in fact, set up the sampling stations and sites, at the locations shown on that exhibit?

A Along these different radii. Of course, they won't be right on that line, on those lines. They will vary because of various reasons that I went under deposition on, the reasons being, if the land were leased land from the federal or state government, we tried to have our plots on federal and state leased lands. We tried to have them on exposed sites in the area, the more elevated sites in those areas. We tried to make them Ponderosa pine sites, and so on, so it would vary a little off each radii. There was never an ironclad rule that we had to be right on those different radii.

Q Did you undertake to select these particular sites?

A Personally?

Q Yes.

A A large number of them, not all of them.

Q Who else participated in the selection of the sites that were ultimately established?

A Phillip Tourangeau and Charles Kaye, primarily.

Q Was there anyone involved from the Department of Natural Resources?

A Not that I remember, no.

Q Did you consult with anyone in the Department of Natural Resources relative to the establishment of the sites or did they more or less leave that up to you in accordance with the proposal?

A I think they left it up to us primarily, but I should mention that we did keep them informed of where our sites were; in fact, we had some help from various people here in the State Capitol, for instance, Mr. Schwinden; also, I think, from Bill Christianson, dealing with a few of the ranchers and farmers when we needed to trespass upon their property.

Q I am handing you what has been marked as Applicants' Exhibit No. 240 and will ask you if that did not represent the ultimate location of sites which your group and you selected?

A No, this does not. These are sites here on what you call Exhibit 240 of some of the sites that we have, I believe, for the DNR and also sites, I believe, that are also some EPA sites, and there could be some ERDA sites here, I believe.

Q But doesn't the exhibit reflect a selection or show sites which were selected in accordance with the proposal?

A It shows those sites, yes.

Q I realize there are more sites on there than those which you selected for the DNR contract.

A There are also places on here where there are sites, and they are not marked, sir.

Q I see. Okay, but the selection of those sites was in accordance with the proposal that you made to the DNR and which you then ultimately selected as far as your selection of baseline data is concerned?

A That is correct.

MR. PETERSON: We'll offer Exhibits 239 and 240.

MR. SHENKER: No objection.

HEARINGS EXAMINER: If there are no objections, Applicants' Exhibits 239 and 240 will be admitted.

Q With regard to both the exhibits, 239 and 240, was there consideration given at the time by your group or the Department of Natural Resources to include any sites on the Northern Cheyenne Reservation?

A I had two or three sites on the Northern Cheyenne Reservation.

Q And did you take baseline data from those three sites before you prepared your draft to the DNR?

A That is correct.

Q What was the purpose of locating the sites on the Northern Cheyenne Reservation?

A Primarily, from the data of Dr. Arden Super, the meteorologist, and also, the studies of Dr. Heimbach.

Q And that was to gather data on the reservation relative to the potential effects of the pollutants hitting the reservation?

A That is correct.

Q Did you develop baseline data on the reservation for that purpose?

A Yes, we did.

Q Did you consider, then, that the Northern Cheyenne Indian Reservation was, in fact, included in the study area that you worked on under contract with the Department of Natural Resources?

A A very small portion of the Northern Cheyenne was, indeed, part of our DNRC report.

Q What small portion?

A The plots that were located on that reservation and the vegetation that we collected from that reservation.

Q What are their general location? Are there three of them?

A I think there are two. I know there are two. There could be a third one. I forget the one to the southwest, and I don't know whether that was right on the border of the Crow Reservation and the Cheyenne Reservation or not. I would have to look that up.

Q Were the other two on the northern border of the Cheyenne Reservation?

A No, one was on the eastern border down close to the Tongue River, and the other one was close to a lookout on top of the ridge going over from Lame Deer to Ashland. It's towards the northern end of the reservation, yes.

Q Was the Tribal Council on the Northern Cheyenne Reservation alerted to the fact that you were implementing monitoring sites on the reservation?

A Yes, they were.

Q And did they accede to your request to set up those sites?

A They said we could set up those sites.

Q They did give you permission?

A That is correct.

Q Did you explain to them, Dr. Gordon, what the purpose of the sites was to be?

A Yes, I did.

Q Of the 40 graduate students who are working for an MS in the field of environmental studies, how many of those are personally directed by you, all of them?

A Oh, no, heavens, no. I think I have five or six; something like that.

Q Do you have any applicants for a PhD under your tutelage at the present time?

A I have two.

Q Is one Mr. Carlson?

A Mr. Carlson is on a leave of absence from the U.S. Forest Service and he reports down there twice a week and does some work, but he is pursuing his PhD work at this time.

Q Does his PhD work or thesis have to do with the studies he's doing at Colstrip?

A Partially, but they also include studies from Addy, up by Colville, Washington, on the Addy plant. It's a magnesium plant that's going in there. It will also include some of his work in various other areas where pollution damage is occurring to vegetation.

Q Of the five individuals you supervise for a Master's Degree, how many will complete their degrees this year?

A Two that I know of.

Q May I assume, then, that the other three will complete their work next year?

A That is correct.

Q How many professors or associate professors are working at your laboratory of environmental studies? Is that the name of it?

A Laboratory of Environmental Studies, right. There are no professors other than myself, per se, who are working in the laboratory. There is one person who is a PhD entomologist from Montana State university who works in that laboratory for me under grant contract; there is another student who is just getting his PhD. He's just finished his thesis. Everything has been completed except for me passing his final draft of his thesis.

Q When did you first set up the laboratory?

A In 1964 -- '63, in that area, is when I first started to become involved in air pollution studies to any extent, and that was in Garrison, Montana.

Q What kind of equipment do you have in the lab?

A The equipment in the lab is a gas chromatograph atomic absorption for heavy metals, a fluoride probe, a Leco induction furnace for sulfur spectrometers of various types, an infrared spectrophotometer -- there are other things there for water pollution studies and this type of thing.

Q Are all of the instruments which you just mentioned in your testimony here related to Air pollution?

A Many of them are. You can use, I believe, everything that I mentioned, for air pollution studies, yes.

Q Who was in charge of the laboratory?

A Phillip Tourangeau.

Q How long has he been engaged in that activity?

A Since 1969.

Q How is the laboratory financed?

A The laboratory is financed primarily through research grants and contracts with federal and state agencies.

Q Is that through the University of Montana Endowment Fund?

A It comes into the University of Montana foundation, and I think it goes directly now to the state instead of the foundation, if I am correct.

Q What would you say would be the amount of expenditures that have been made on laboratory equipment since you instituted the laboratory in '63 or '64?

A I would say, counting the surplus supplies, that we got through surplus, which made it much cheaper, somewhere in the neighborhood of sixty to eighty thousand dollars.

Q How large is the laboratory physically, its physical size?

A Its physical size is approximately -- there are actually four laboratories; the main laboratory, where most of the equipment is located, is approximately 40 x 40 feet; the preparation room, the media room, also where the grinding is carried out, and so on, is approximately 18 x 18. The photograph room is about 18 x 20. The micro-technique room, which is also partly an office for my secretary, is 20 x 20, and my office is 18 x 10, with no carpet.

Q What kind of anatomical study equipment do you have in the laboratory?

A We have entire equipment for (?) microtoming, for ice microtoming, and upstairs, we have equipment for plastic sectioning.

Q Do all of the students who are in the botany department at the University, together with those who are seeking their Master's and PhD degrees have access to the laboratory for their studies?

A Yes, if they request it and need help on certain projects, all of those labs are available. The photograph lab, especially, is available to all students. I forgot about the darkroom which we built. These are all available. We do help students. We let them use the atomic absorption, the sulfur analyzer, the fluoride analyzer. I think that in general we can say that we're fairly open about using our equipment.

Q Would you say that the laboratory, however, is basically -- has been basically set up to do research work rather than to assist in education?

A No. I also use that laboratory for my forest pathology class, for my water pollution class, and for my air pollution class, under duress.

Q Why duress?

A Because of the fact that we have lots of people working in the lab, and this slows down our work sometimes when the classes are there.

Q How many people would average out in a day working in the lab?

A Currently, there are twelve people in all of the labs.

Q Is the greenhouse that you referred to in various parts of your testimony associated with the lab physically?

A No, it is attached to the physiology lab on the annex of the natural science building.

Dr. Gordon, on page 4 of your statement, you cite agricultural statistics in seven counties of southeastern Montana. I wonder if you could relate for the record the names of those seven counties?

A Not all of them right now. Of course, there's Rosebud, Treasure, Custer --

Q Would Powder River be in there?

A Right.

Q How about Big Horn?

A I haven't got my map here. Unfortunately, I have it up in my room. I didn't bring it this morning. I will have it here this afternoon.

Q Maybe you can get it at noon.

A Yes, I will.

Q So we can identify the seven counties.

A Right, will do.

Q Do you know the total number of acres that are involved in those seven counties, that is, acres of farmland, that are included in those seven counties?

A No, but it is in the agricultural statistic book. I did not memorize those numbers.

Q What is the source of your data, then?

A It's the USDA, Montana Department of Agriculture statistics, 1973, the latest publication they have out at this time, or when I wrote my report.

Q On line 25, you state --beginning at line 22 -- you state, "The agricultural statistics, which are not available in the annual statistics reports by the Department of Agriculture, but are also pertinent to evaluating and real and potential impact of coal-fired power plant emissions upon agriculture in this area of Montana, should also be considered." Do you mean by that statement to state that the 7-county area which you refer to above is going to be affected by the power plant emissions at Colstrip?

A That is correct.

Q What would you expect the magnitude of the effect to be?

A As far as damage is concerned?

Q Yes.

A That depends on many things. One of the things it depends on is how accurate the data is that we have from the Board of Health's findings of facts on the actual emissions or the proposed or thought of emissions from Colstrip 1 through 4, if 3 and 4 do, indeed, go on line. If that is correct, and there is that 58,000 tons of SO_2 per year, I think it's about 60 thousand some tons of nitrogen oxide, about 20 tons of fluorides, trace metals, abundant trace metals. I would say the extent of the damage would be very widespread and serious.

Q Could you give us a percentage figure?

A No, I cannot.

Q Are you relating that damage, that widespread damage, to cash value of farm products or productivity, or what parameter?

A The damage itself will be a reduction in the growth parameters currently occurring, therefore, the baseline that's currently occurring. There will be an increase in the amount of sulfur and fluoride accumulation in the vegetation in the area. There will be from the acid rain damage to the air, which will cause a reduction in biomass. As I state in my report, baseline studies have never been done prior to a power plant this size ever going on line before.

Q What do you anticipate would be the reduction in crop production from any of these effects of the air pollutants?

A Would you restate the question?

Q What would be the reduction in crop production in the 7-county area from the effects of the air pollution?

A That depends upon those farms that are impacted the most to those that are impacted the least. I expect that some farmers will go out of business.

Q How many?

A I have no idea.

Q That's pure speculation?

A That they will go out of business?

Q Yes.

A I think that's fairly well true from most of the areas I have worked in air pollution studies, that the companies, after they pay damages, usually buy the farms that have the greatest impact upon them. I cannot think of a single place that I have not worked where the company has not bought some of the ranches around their stationary source except in Garrison, Montana.

Q What will be the total percentage reduction in the 7-county area in crop production, assuming that some of these ranchers, according to you, will suffer 100% damage?

A What will be the percentage of damage to the farms x-miles away from the source?

Q In the 7-county area to which we are referring.

A It will cause a decrease in the productivity of that area; what percentage, I have no idea at this particular time.

Q Over what period of time will these effects take place?

A The effects are obviously starting to occur now, when 1 and 2 go on line.

Q What are the present effects, then, from No. 1?

A We have not done our spring collections yet.

Q Have you noticed any effects taking place since No. 1 went on line in September of last year?

A No, I have not. I have not been there except once. No, I have not been there since that time, either.

Q Have you been given any reports of any effects taking place?

A I don't know anyone who is collecting vegetation who is down there except our kids who are collecting primarily air-monitoring data and collecting animals.

Q When you say "our kids," you mean your students?

A No. Anyone under 48 is a kid. There are full-time employees down there staying in the trailer courts at Colstrip during the entire winter, who are collecting animals, air-monitoring data, and so forth.

Q Are you looking for damage to the 7-county area from sources other than the effluents from Colstrip units 1 and 2?

A Yes.

Q What other type of damage, what other type of area are you looking at, which would cause an effect to the crop production?

A Maybe I'm not following your question. I thought you were asking me if there was going to be other influences in the Fort Union Basin that could cause damage to that?

Q That would be one area. What I'm asking you about is whether or not you're looking for effects on crop production or vegetation other than from effluents from the stack?

A Not that I can think of right offhand; however, we would worry about herbicides and the use of herbicides. We've been trying to gather that data on herbicides.

Q Why didn't you include that data in your study in 1973 and 1974 when you were collecting the baseline data for the state?

A Because the state has kept extremely bad records on herbicides used throughout most of eastern Montana.

Q Can't you determine that from a survey of those who are using the herbicides?

A No. I've called the County Agents throughout the Forsyth area, and I also called Gary Gingrey, who heads up the herbicides for the Department of Agriculture, and he has sent me some data. It is totally incomplete to make any reports on herbicides.

Q Do you have any baseline data collected as to what the effects of herbicides have been on this 7-county area as far as crop production is concerned?

A The data I do have is that there are very little herbicides utilized in that area.

Q What type is utilized?

A You mean what types of herbicides?

Q Yes.

A There are contacts and there are hormonal types. Of the small records I do have, primarily contact and hormonal.

Q What is a hormonal herbicide?

A 24D245T.

Q What is the purpose of spraying that herbicide?

A It's primarily to eradicate dicotyledonous types of plants, weed-type plants, in specific areas, of the hormone types. You're saving the grasses and this type of thing, the monocots, or eliminating the dicots from the monocots.

Q Are you making any other studies or collecting any other data as to potential damage to the crop production in that 7-county area other than from the effluents and the herbicides?

A No, our baseline work is primarily with indigenous species, in that the No. 1 production in that area are the domesticated animals in that area. I can't think of anything besides herbicides, all types of air monitoring data, as well as vegetative data.

Q Are you getting any data on insecticides?

A No, we have not gathered any data on insecticides.

Q Would you consider that to be relevant?

A Yes, I would. Not as far as crop loss, as far as -- I shouldn't say -- I'm sorry -- my entomologist is collecting data on insecticides.

Q Who is he?

A His name is Dr. Jerry Bromenschenk, and we have done insecticide work on the bees collected throughout most of that 7-county area.

Q With regard to the bees, is it reasonable to assume at this time that the honeybee damage will occur?

A Yes.

Q And if so, what data do you have to document the validity of that statement?

A The only study I could find along that is that there is one study showing death of honeybees for a 3 to 4 mile radius around a coal-fired power plant.

Q Where is that? What study is that?

A I'd have to look it up.

Q What power plant?

A I'd have to look it up, I'm sorry.

Q Could you get it for me?

A Yes, I can.

Q Do you know of any other study, Dr. Gordon, other than that one study, relative to honeybees?

A Around coal-fired power plants?

Q Yes.

A No, I do not. As I said before, most of the -- this is the only study through baseline studies around a coal-fired power plant prior to the plant going on line. The studies around other power plants, like TVA plants and other things like that would be after the fact, so I don't know if it's relevant.

Q What was the cause of the damage to the honeybee population from that power plant?

A Primarily it was caused by arsenic from the trace metal particulate.

Q Was that power plant equipped with any air pollution abatement equipment?

A That I don't know at this time. I'd have to look at the article, to see if it said anything about it. I don't remember it saying anything about that.

Q Do you have any idea at this time what fumigation levels will be required to significantly affect the honeybees?

A We are currently carrying on studies on that and we are putting colonies on our ZAP plots down in the Taylor Creek area to see if we can determine what the effects of the various concentrations of sulfur are to those colonies.

Q Are you using such sulfur dioxide?

A Yes, that's the only thing we're using, unfortunately.

Q Why wouldn't you be using arsenic?

A I'd like to use all of the effluents -- I mean emissions -- from a coal-fired power plant, and I've suggested that in my reports to EPA. The cost is too great, they tell me, so we cannot use anything else besides sulfur dioxide.

Q Why would you select, if restricted money-wise as to what they're going to grant for the study, why was the decision made to study the effects of SO_2 rather than the effects of just arsenic?

A The studies themselves were not set up per se to study the effects upon honeybees. The studies were set up to see the effects of various concentrations upon the indigenous grasses of the Colstrip area.

Q So you just threw the honeybees in as part of a further study because you already had the ZAP plot set up for the SO_2?

A Even in the original proposal I made to EPA, the honeybees and other insects and fungi were included on the ZAP sites to see what the biological effects would be upon these other organisms, such as insects and fungi.

Q With regard to the levels of fumigation that you speak about that will damage the honeybees, are you able to identify on the Exhibits 221-A or 221-B where such damage will take place by reason of the fumigation?

A No. I do have a map in my lab that Dr. Bromenschenk has put together showing where the colonies are located during the various times of the growing season. I have not spent any time trying to estimate any type of impact upon those bees by sulfuric acid or nitric acid or fluorides at this particular time.

Q Were those colonies selected just traditionally? Has there been an historic pattern, or was there a reason that the colony location was selected?

A No, Dr. Bromenschenk is working with the farmers. This is their normal place where they put their colonies. They have donated, I forget how many colonies, to our study. We can manipulate those colonies in that area as far as where we place them, and so on, but I think it's a few numbers as far as colonies are concerned. We are only working with the beekeepers to see what the pattern is currently with those bees, and also find out what the insecticide levels are in those bees, and so on.

Q Have you examined any of the meteorology studies to determine whether or not those bee colonies are going to be in fumigation areas?

A Yes, they will be in fumigation areas.

Q Are those meteorology studies that you examined the work that was done by MSU?

A Yes, it is.

Q Where are the particular areas where you have related the honeybees will be affected because of the meteorology data?

A The bee colonies are primarily kept along the various drainages, such as Rosebud Creek, Cow Creek, Tongue, Powder River, Sarpy Creek, and so on.

Q Where did you get the figures that the southeast -- and I assume when you say southeast, you're talking about the 7-county area, or am I wrong?

A In the bees, I've added two other counties which I talk about here, because of the fact that this is where Bromenschenk has included -- I've included Treasure plus Big Horn County.

Q Where did you get the figures relative to the harvest amounts?

A That is from the beekeepers as well as from the head beekeeper -- I mean the head -- what do you call him? Just a minute, and I'll think of it.

Q Apiarist?

A That's close enough. The data on the bee colonies, the amount, the value of the honey, and so on, is all collected by Dr. Bromenschenk for me, and he collected it from the beekeepers and from the state agency.

Q The retail value figures here that you're reciting in your statement on page 5, are those taken from the beekeepers or from the state records?

A That is taken from calculating -- that is 1975 data. That is taken from the going price of the honey this last year and from the beekeepers, I believe.

Q And then did you make the calculation?

A Yes, I did.

Q So this figure would not be reported in any state document that you know of?

A That is correct.

Q Did you have any correspondence or any discussions with the Montana individual at the Department of Agriculture relative to the total economic value of honeybees in the state of Montana?

A Yes, I do have that. In fact, I have that in the notes on my desk, which Dr. Bromenschenk collected for me.

Q Is that figure different than what is shown as to Dr. Moeller's estimation?

A I can tell you this, that out of the 80,000 honeybee colonies in the state of Montana, 20,000 of those colonies are taken to California to the almond groves in California in the fall of the year. How much money is made by the beekeepers from the pollination of the almond groves, I don't know. I think Dr. Bromenschenk does know.

Q How many of those 20,000 come from the 9-county area that you relate to in your statement?

A I don't know that.

Q Do you think it would be approximately 8%?

A I really don't know that.

Q Do you have any information at this time, Dr. Gordon, as to the known levels of particulates or fluorides or sulfur in honeybees?

A Yes.

Q Would you relate those?

A I do not have that data. I could find it at lunchtime for you.

Q Was that data collected in Montana?

A It is part of our baseline studies, that is correct.

Q When did you begin the baseline studies on the honeybees?

A 1974, with a $58,000 grant from the Environmental Protection Agency EPA N.E.R.L. Lab.

Q Are those known levels published anywhere?

A Yes, they are, in reports to the Environmental Protection Agency and in publications by EPA of our studies.

Q When you get some time out of your busy schedule, could you supply me with a copy of those reports?

A You are talking now about the report from Bromenschenk?

Q I guess that it would be -- relative to the levels, the particulate levels of sulfur and fluoride and so forth, in the bees that you had as part of your baseline.

A Fine.

Q In making your analysis that there will be damage to the honeybee colonies in the southeastern colonies, have you considered the proposed ground level concentrations which are recited in the findings of fact and conclusions of law entered by the Board of Health?

A Not at this time, I have not, but I would like to make sure that you don't infer to the record that honeybees are the only important pollinators throughout that area. I just use it as an example. There are many hundreds of insects there which are very beneficial for that ecosystem in the Colstrip area, and some that are also damaging.

Q Have you made an analysis in your baseline study as to the effects of the effluents on those other species?

A No, we are now doing the survey of what those other species are. I can't remember right offhand if we're collecting enough of those for chemical analysis or not. I really can't remember right now. I can find out during lunch period.

Q When did you begin that study on the other species?

A That's also in 1974. This is an EPA-funded study, and I hired Bromenschenk in '74, and he started right off on the insect work.

Q As I understand your testimony, you are unable to predict where the ground level concentrations will, in fact, occur, in and around Colstrip which will cause this damage?

A To insects?

Q Yes.

A I cannot tell you at this time.

Q What other species are you examining other than the honeybees, of the pollinating species? Just give me a few examples.

A There's a black -- I can't remember the name. I'm sure that Dr. Bromenschenk would be willing to come and testify to all of the insects, the beneficial and the damaging insects in the area of Colstrip.

Q Were those species included in the report for which I just asked?

A Yes, they are.

Q Are honeybees affected by oxides of nitrogen levels, effluents?

A At what concentrations?

Q At any concentration.

A Not that I know of.

Q Are they affected by any concentration of hydrogen fluoride?

A Yes.

Q Do you know the concentration?

A The concentration on the flowers, or the concentrations in the ambient air, or the concentrations where?

Q What would be the maximum concentration that would be required of hydrogen fluoride that could have an adverse effect on honeybees?

A We don't know that, but we do know that when the honeybee dies, it's around 100 to 300 parts per million of fluoride in those bees. We have collected them in the areas of Anaconda, also, from the Dalles,Oregon area. The baseline is below ten parts per million, if I remember correctly.

Q Are you stating that the cause of death in those honeybees in those areas was from the fluoride?

A No.

Q Are you doing any work on the potential effect of ozone levels in the area affecting honeybees and their production?

A Not at this time, no, but we are carrying out with other agencies the concentrations of ozone in the area, or baseline.

Q With regard to the samples or the species that you took in the Anaconda and the Dalles, Oregon area, when was that?

A The Anaconda -- Columbia Falls, pardon me -- Aluminum plant was last year, and the Dalles was during the Meyers case and I think that was '73 or '74. I cannot remember.

Q Did you examine the bees in the Columbia Falls or the Dalles, Oregon areas for levels other than hydrogen fluoride?

A I do not know as far as Columbia Falls is concerned if Bromenschenk sent those away to the USDA lab for other types of analyses. The study from the Dalles, nothing else was done besides fluoride analysis.

Q Would it be accurate to say that the work that is being done in this area relative to honeybees and these other species is principally being done by Dr. Bromenschenk?

A Yes, that is his responsibility.

Q And you will rely upon the data that he gathers rather than gathering data independent of his work?

A That is correct.

Q Do you know of any instances, Dr. Gordon, that you've come across in your studies, where colonies of honeybees have been materially affected by power plant emissions?

A Just what I referred to before.

Q Just the one study?

A Just the one study, yes.

Q Do you know who did that study?

A I can find out. As I said, I'll bring it back at our noon recess.

Q We might have a few questions on it then. With regard to your section under "Timber Resources," you mention that Ponderosa pine has numerous known and unknown influences, upon the understory species of vegetation, fauna, insects, and so forth, and the physical environment of soils, soil moisture, nutrients, and so forth. What are some of the known influences?

A There's an increase in acidity on a coniferous forest, Ponderosa pine included, and there is a difference in vegetation species under a Ponderosa pine and out on the open savannas. There will be more microorganisms, in some cases, that are related to -- for instance, the mycorrhizae fungi for the Ponderosa pine species. There are both predator insects and destructive insects there that you will not find in other areas of grassland biomes. There are different series of fungi, many different types of fungi within that microcosm of the Ponderosa pine that you will not find in the grassland itself, where the Ponderosa does not grow.

Q And when you make your statement, you state "unknown influences." What are unknown influences?

A These are things we simply do not know. We do not know the interrelationships of some of the organisms, the soil microorganisms, to that coniferous forest, the Ponderosa pine, and yet we know that they are essential to that, a very intricate part of that cycling there.

Q Are there any large timber areas or stands within 15 miles of these plants?

A Yes.

Q What is the closest timber stand from the plant, do you know?

A I believe that the closest big timber stand should be Leo Farley's stand where he sold 6,000,000 board feet, back in 1972, when I talked to him on that mountain range between Sarpy and Colstrip.

Q To whom did he make that sale?

A I don't remember that.

Q Is the usual management of the Ponderosa pine in that area that of even age or uneven age stands?

A It's uneven age stands.

Q In your Exhibit 221-B, what management is employed in the

Colstrip region timber management as shown on that exhibit?

A Is it B you're talking about?

Q Yes.

A I don't understand what you're saying here now. Are you asking me where it says 12 there?

Q What kind of timber management practices do they engage in?

A The No. 12, as I understand it, is Ponderosa pine.

A That is correct. On the Custer and on the Northern Cheyenne, they thin, they fire, they use some fire work on these areas, they use the Ponderosa pine savannas for grazing, which they make most of their money on, both from Custer and the Northern Cheyennes, at the present time. They mark out sales on both the Northern Cheyenne and the Custer. They do a lot of fire protection work. They do a lot of soil erosion work. They carry out insect and disease surveys.

Q Do they do any clear-cutting?

A I'm not aware -- well -- no, I'm not aware of any large or even moderately large clear-cutting in the area. It's mostly selective cutting.

Q What is the purpose of the selective cutting as a management practice?

A They use it because of the uneven age stand, and they take the best timber and leave the other trees that are not at the peak of their growth. A Ponderosa pine grows in such a way that it reaches its maximum growth in the neighborhood of about 250 years, which is the fastest growth. Unfortunately, the Forest Service cuts at about a hundred years' growth on Ponderosa pine.

HEARINGS EXAMINER: Gentlemen, whenever you have a convenient stopping place, we'll recess for lunch. What I'd like to do, if this meets with everybody's approval, we'll recess Dr. Gordon's cross-examination at 1:30; however, since he has some things to gather up and we have some things to look at, I'd like to take this gentleman as a public witness at 1:00 o'clock, since a different counsel is involved.

MR. PETERSON: That's fine.

HEARINGS EXAMINER: Then we'll recess as far as Dr. Gordon is concerned, and if Mr. Myren will be here at 1:00 o'clock, we'll take him as a public witness.

(HEARING RECESSED AT 12:00 NOON.)

The hearing was reconvened at 1:07 P.M., following the lunch recess.

HEARINGS EXAMINER: Let us proceed.

ALBEN T. MYREN, JR., appearing as a public witness, having been first duly sworn upon his oath, both as to his written direct testimony and as to the oral testimony to follow, was examined and testified as follows:

(THE WRITTEN DIRECT TESTIMONY OF ALBEN T. MYREN, JR. WAS DIRECTED TO BE INSERTED AT THIS POINT.)

313 B Sisson Apts.
Missoula, Mt. 59801
March 3, 1976

RE: Colstrip Units No. 3 and 4
Position: Firmly Against

Statement:

My name is Alben (Ben) T. Myren Jr. and I am a resident of Montana and reside at the above address in Missoula. I have a B.S. in Animal Science from the University of Illinois, Urbana (1967) and have worked as a production supervisor and as an industrial engineer for the Rath Packing Company in Waterloo, Iowa. I am on the verge of fulfilling the requirements for an M.A. in History from the University of Northern Iowa, Cedar Falls and I am presently a graduate student in the Environmental Studies program at the University of Montana.

I am against the approval of units 3 and 4 for the following reasons: (1) there has been no attempt to define what constitutes need, (2) the impact of the units on the lives of the residents of Eastern Montana, (3) the impact of the units on human beings outside of Montana, and (4) the impact on future generations. I will now develop each of these reasons in more detail.

Need

Thus far I have not heard of what the electricity generated by units 3 and 4 is to be used for, other than to meet projected demands in the last half of the 1970's and of the early 1980's. Recent federal government studies show that Americans waste about one-quarter of the energy they consume and that only about one-third of American industry has seriously undertaken steps to reduce the energy it consumes.

This wasteage and over consumption is furthered by declining block rate structures in which the cost of energy is reduced as one consumes more. What then is the energy of 3 and 4 to be used for? To continue the wasteful habits of the past and present? Here I would submit that useage is not a reflection of need and that the permit can be denied on the basis of need alone.

Not only have there been no real concerted efforts at energy conservation in this country, electricity is sold at varing prices throughout the country. For example, the cost of electricity on a per KWH basis varies within the projected market area for Units 3 and 4's production, with Montana's rates being the highest. Are we as Montanan's now being asked to subidize the consumptive patterns of other people? The cost of generation per KWH should be the same, no matter who consumes the electricity. Certainly before any permit is granted a rate equalization should occur within the entire Northwest power grid so that the price of electricty accurately reflects the cost of generation to the consumer. Without such a rate equalization, there can be no demonstratable need, for the present price paid by some of the consumers in the Pacific Northwest is too low.

Social Impact in Montana

I think that each of us should ask ourselves why it is that Units 3 and 4 are to be built here in Montana rather than in the area where over 50% of the electricity produced by those units will be consumed. Why is it that Montanans will not only have to have their land destroyed, both physically and asthetically, but also have their air polluted by the plants that will burn the coal? I ask you, what gives any person the right to destroy another man's way of life? Does money provide that means? Certainly not!

I think it is time that we asked ourselves about what type of society it is that we wish to see realized in this country. How many of us would like to see his own backyard ripped up and air polluted to provide energy to people who have not made any serious efforts to cease their wasteful uses of energy? The answers would be dam few, if any. Yet this is the very thing that is happening to the residents of Rosebud country and Eastern Montana. If you would not be willing to have similar events happen to you, you can not ask it of others. And if you are unwilling to have it happen to you, then there can be no need.

Social Impacts Outside of Montana

How can anyone as a human being justify the destruction of one acre of cropland, however, "temporary", in a world in which people starve to death every day! What gives any person the right to demand that another person be condemned to a death by starvation because he needs an extra kilowatt hour or two. Yet by strip-mining coal in the eastern part of the state we are doing just that. We are removing agricultural land from production, land that could be producing wheat or beef - and with those removals yields drop and some where some one has an empty belly because of it. Whose need is more important? The one who is concerned with getting enough to eat, or the one who wants an extra kilowatt or two to increase his standard of living?

And then what about the impact of pollutants, particularly sulfur dioxide (SO_2), upon crop yeidls? How can any one justify even the possibility of reducing crop yeidls in a world in which starvation is a very real threat to a large number of our fellow men? Again, whose need is more important? There can be only one answer, and that answer requires that the permit be denied.

Impact Upon Future Generations

If one listens to what is being said in these hearings, it seems that something must be proven harmful before it can be regulated. This, it would seem to me, puts the cart before the horse. Shouldn't something be accepted only after it is proven by lengthy research to be non-harmful? Such is the case with many of the present emission levels for various pollutants. What are we doing to the earth's life support system? Do we know? And if not, isn't it time we began to find out before we undertake any activities that might further exasperate a situation over which we have no control and very little real knowledge. Just what does entail environmental compatibility? Are any of us willing to step forward and say this is "it" and then be willing to accept the consequences if he is wrong. Yet we are forcing future generations to accept the consequences of our actions without fully knowing what those consequences might be!

Now How far into the future do we extend our feelings of obligation? The best estimates of this nation's coal reserves state that at present rates of consumption, those resources will be gone around 2400 A.D. So what are the generations that come after 2400 to do? Do without? Certainly there are much more important long term uses that the coal that is to be burnt in Units 3 and 4 can be put to. The lack of any serious conservation efforts to date, already indicts us, but to continue to foster the wasteful consumption of a non-renewable resource, coal, by granting a permit leaves one with the conclusion that we are more concerned with the present than with the welfare of our descendents. What kind of world do we wish for them to inherit? One which has been depleted of all of its non-renewable resources in order to sustain a standard of living in which waste is rampant? I thing not, and here again the question of whose need is important is one that must be answered.

Summary

The real importance of the environmental world view is that it has challenged many of the basic assumptions upon which the industrialized world has been founded. We can try to deny that world view and insist that we can make tradeoffs between environmental quality and other considerations. But we can not. All we do by making those tradeoffs is to perhaps forestall the day of reckoning and pass the buck to some other time and generation. Tradeoffs are the easy way out. Some one, some time is going to have to say "No". Let that some one be us.

Let us assume moral responsibility for what we do and say "No" to this application and begin to construct a sane world by telling the rest of the nation that we would rather conserve on what we have and use than to continue on as before, a pathway that will have a day of reckoning that might not be as easy as merely saying No.

HEARINGS EXAMINER: Mr. Bellingham will conduct the cross-examination.

EXAMINATION OF ALBEN T. MYREN, JR.

Cross, by Applicants

By Mr. Bellingham:

Q How old are you, sir?

A Thirty-one.

Q And I see you are going to the University of Montana as a graduate student?

A Right.

Q Taking an Environmental Studies program?

A Right.

Q Are you reaching for a degree at the University of Montana?

A I expect to get my Master's Degree there this summer or coming fall.

Q And who is the instructor of the Environmental Studies -- in charge, I should say.

A Who is my particular advisor?

Q Yes.

A Probably Dr. Huff, of the Philosophy Department, and Dr. Maxine deWetering of the History Department. Those are probably the two principal people that I've worked under.

Q And is Dr. Clancy Gordon a professor in the Environmental Studies at all?

A He's a director of the program and he does teach some courses.

Q He's a director of the Environmental Studies. He was on the stand immediately prior to the time you came, is that right?

A Right.

Q I assume that you prepared your statement here?

A Yes.

Q Did you have some help with it?

A No.

Q From any source whatsoever?

A No.

Q No one else put any input into it at all?

A No, I sat down and wrote that last night myself.

Q Now, you say that "Recent federal government studies show that Americans waste about one-quarter of the energy they consume." What government studies are you referring to?

A I can't give you the citation. I forgot to bring my folder, but it was in The Missoulian. That's all I can tell you.

Q The Missoulian paper?

A Yes.

Q The Daily Missoulian?

A Right.

Q And you're relying upon the Daily Missoulian, then, for that statement, is that right?

A Yes. They gave the name of the study.

Q And Americans waste about one-quarter of the energy they consume?

A Right.

Q But you're not sure what the study was?

A No, I can't give you the specific title.

Q You say also, that "About one-third of American industry has seriously undertaken steps to reduce the energy it consumes."

I assume, then, that the same thing applies to it as the previous statement?

A Right, it was also an article in The Missoulian.

Q You picked it up from The Missoulian, and it referred to some article?

A It referred to a study done by -- I think the latter one was done by the Federal Energy Administration, if I remember correctly.

Q Have you read the articles that The Missoulian referred to?

A I've read parts of the first article. I haven't been able to obtain a copy of the second article.

Q Now, you talk on page 2 about what the energy from 3 and 4 is to be used for, and that the permit had been denied on the basis of need alone. I don't think you've sat in on any of the sessions over here, have you, relative to 3 and 4?

A No, I have not, but I have been following them in the papers, and I've seen some of the copies of the testimony.

Q Whose testimony have you seen copies of?

A I can't recall.

Q Did you read them?

A I read parts of them. I haven't had a chance to read it all.

Q It would be a very small part of the entire transcript, isn't that right?

A Yes.

Q And you haven't read the transcripts as such, other than what you've already testified to?

A No.

Q You haven't seen any of the exhibits, I assume, have you?

A No.

Q You state that the cost of generation per kilowatt hours should be the same no matter who consumes electricity. Are you talking there on a nationwide basis?

A Yes, sir, I am.

Q You feel that the cost of electricity should be the same, regardless of what section of the country it is, regardless of the cost of that electricity, or any of the factors that go into making up the cost of electricity, is that right?

A I think that if you're going to consume electricity, you should pay the true cost of the real cost of that electricity. That not only includes the costs of generating the electricity, but also, the cost of transporting it from the site of generation to the point of consumption.

Q Are you saying here that the cost to a consumer should be the same to everyone throughout the country?

A Yes.

Q Irrespective of the costs of generation?

A I'm not talking in dollars and cents. What I'm saying is that the difference in generation costs vary between power plants. What I want the cost of electricity to reflect to each individual consumer is the true cost of the generation of that electricity. Now, the cost of generation between plants might vary, but still, the cost of the electricity that is consumed should reflect that; in other words, it's going to cost you so much money to generate kilowatt hours of electricity at Colstrip 3 and 4, no matter who consumes it, and the price of that electricity, no matter who consumes it, should reflect that cost.

Q You talk about wasteful uses of energy throughout your statement here, and you're not limiting that comment to people outside the state of Montana, are you?

A No, it occurs within the state, too. I just went down and had a lunch and I walked to the parking lot, and there were probably 15 or 20 aluminum beer cans just pitched out. That's a waste of energy, electricity, in particular.

Q Did you pick them up?

A I did a couple.

Q Two out of fifteen. You say strip-mining coal in the eastern part of the state, we are condemning people to death by starvation.

A Yes, sir.

Q Now, are you against all strip-mining of coal?

A Am I against all strip-mining of coal?

Q Yes.

A If it takes up land that produces food, I am.

Q Well, generally, strip-mining of coal is going to take up land that produces food, isn't it?

A Probably, yes, sir.

Q Do you know of any instances where it isn't?

A I'm not sure whether all the land that's been stripped, like in Appalachia, could produce, you know, like grain. Some of it probably primarily produced forest products.

Q Well, also, grass?

A Okay. If you want to consider grass as food for the digestive system, then I would say yes.

Q So you are against any kind of strip-mining that in any manner takes up any land that is productive in any sense?

A Right.

Q And that takes care of all strip-mining in eastern Montana, doesn't it?

A That's correct, or elsewhere in the world, for that matter.

Q You're aware, aren't you, that Montana has what's been termed the strictest conservation laws in the United States relative to strip-mining?

A I don't feel they're strong enough.

Q I see. You'd rather see them stronger?

A Yes, sir.

Q And you are aware of the fact that the experts state that this land that is strip-mined can be reclaimed to a better state, or at least equal to the state that it was before the strip-mining occurred? You're aware of that, are you not?

A They claim that; they haven't proven that yet.

Q You don't believe it, then?

A No.

Q In other words, you disagree with the experts regarding that point, is that right?

A I don't believe that if you tear up a parcel of land -- I come from the state of Illinois. I was raised on a farm there. I've seen the impact of strip-mining on lands in an area north of my home at Cuba, Illinois, and that land does not produce what it used to produce.

Q Well, you're not familiar with the type of conservation statutes that were in effect at the time of strip-mining in Illinois, are you?

A I can see the results of the reclamation. Whatever the laws are, you know, I can see what the results of the reclamation efforts were.

Q And you haven't compared the reclamation laws of the state of Illinois to the reclamation laws of the state of Montana, have you?

A No.

Q So you really don't know whether they're on a par or not, do you?

A No.

Q And you do not know whether the reclamation that's going to be carried on in the southeastern part of the state under the Montana reclamation laws is the same that's being carried on in other states?

A I've read the Montana law, if that's what you're asking. I have not read the Illinois law.

Q You don't know whether the type of conservation measures going on down there and the type of reclamation going on in strip-mined areas is the same kind of reclamation that has been practiced in other states?

A Probably not, because that area down there is much different than the area I grew up in. I mean, just the amount of annual rainfall alone is about a third of what we get at home, and the efforts are going to have to vary with the type of land that you're trying to reclaim. I think you're right. The effort has to be different.

Q You talk about a delay as far as the impact on future generations and so forth. How long a delay are you proposing?

A I don't understand your question.

Q Well, you say: "Shouldn't something be accepted only after it is proven by lengthy research to be non-harmful," and this sort of thing, and "Isn't it time we begin to find out before we undertake any activities that might further exasperate a situation over which we have no control and very little real knowledge," and so forth. What are you talking about in terms of years?

A Whatever time it takes, and in particular, I'm concerned about the impact on the ecosystem of various pollutants, if you will. Take sulfur dioxide -- we don't really know what's going on.

Q You're saying that everything should be held in a state of suspended animation until we do find out, isn't that right?

A Well, I don't think we need to build 3 and 4 until we do find out.

Q How long a delay are you talking about?

A How long do we anticipate the research is going to take?

Q Well, I'm asking you. Do you have any idea?

A I think 20 years.

Q How much?

A Twenty years minimum.

Q It's your opinion, then, that we probably should delay 3 and 4 for at least 20 years?

A Correct, until that information comes in, and then you might find that you couldn't build it anyway, due to the information that's provided by the research.

Q You state: "The best estimates of this nation's coal reserves state that at present rates of consumption, those resources will be gone around 2400 A.D."?

A Yes.

Q That's about 430 years?

A Right.

Q Where did you get that information?

A From a class in geology. I don't have the citation, but I can get it if you're interested.

Q Well, I assume that you're aware of the fact that other experts have indicated that the coal reserves will last a lot longer than that; you're aware of that, aren't you?

A Yes.

Q So the experts are not in agreement, apparently?

A No, they're not.

Q So you feel right now that we shouldn't burn any coal whatsoever, if it is being utilized for feed, or for some form of production?

A Well, I'm not against deep-mining the coal in eastern Montana. If you want to take it out that way, without destroying the surface lands, more power to you.

Q What is going to be the substitute for coal?

A What do you mean?

Q Well, if we can't strip-mine our coal at all --

A You can deep-mine it. There's no provision that says you can't go down in the ground and take it out that way.

Q Well, what about the eastern part of the state? Economically, do you know whether or not that would be feasible?

A Well, it seems to me that if you can deep-mine coal that's much deeper than that, it would be economically feasible to deep-mine coal in the eastern part of the state.

Q You haven't made a study of that, of course?

A No, I have not.

Q You don't really know whether technologically it can be done, do you?

A No.

MR. BELLINGHAM: No further questions. Thank you very much.

HEARINGS EXAMINER: Very well, sir, your testimony will go to the Board, and thank you for appearing.

(WITNESS EXCUSED.)

HEARINGS EXAMINER: We'll recess until 1:30.

(HEARING RECESSED AT 1:20 P.M.)

The hearing was reconvened at 1:30 P.M. following a brief recess.

HEARINGS EXAMINER: Very well, Mr. Peterson, you may continue your cross-examination.

DR. C. C. GORDON, having been previously called as a witness by the Department of Natural Resources and Conservation, and having been previously sworn upon his oath, resumed the witness chair for the continuation of his examination and testimony.

CONTINUATION OF EXAMINATION OF DR. C. C. GORDON

Cross, by Applicants

By Mr. Peterson (continuing):

Q Dr. Gordon, with regard to your statement that unit No. 1 is presently causing damage to the ecosystem in the 7-county area, do you have any operating data on unit No. 1 since it's gone on line?

A Only that on two different occasions, we requested on what capacity they are running. I think the highest capacity thus far that I have been told, and it would be hearsay, because I did not get it directly from the company, I got it from one of my field people, who got it from one of the company officials there, was that it was running at 125% -- I mean at 125 megawatts.

Q Any other data?

A The other time, it was running, I understand, at a low one hundred megawatts.

Q And do you consider that data valid, on which you can make an opinion as to whether the ecosystem is presently being damaged?

A No. All I was pointing out was that once you start operating the plant and there are sulfur and fluorides and trace metals and nitrogen oxides coming from that stack, that material will start to accumulate in the vegetation; even during the wintertime, it will accumulate in coniferous species such as Ponderosa pine, because they do accumulate even during, in quotes, the dormant season.

Q What levels of accumulation do you anticipate you're going to see?

A In what?

Q Well, let's take Ponderosa pine.

A I would say that we'll probably see anywhere between -- by springtime -- I shouldn't say spring, because it's almost spring now -- by May and June, we should see concentrations of around a thousand parts per million in some of the conifers close by.

Q How close?

A Oh, about three miles, four miles, from the source.

Q What have been your readings on Ponderosa at the present time on the baseline data?

A It depends. The whole needles, themselves, will run between six to eight hundred parts per million.

Q Is that for SO_2?

A That's for sulfur, total sulfur.

Q Is that normal range?

A Yes, it is, that's baseline, for a pristine, clean area.

Q What would be the fluoride levels that you anticipate that you would find in the pristine area around Colstrip?

A It depends on the species. Some species will vary, but as far as Ponderosa pine is concerned, you should expect anywhere between -- on a 2-year-old needle, a two to three parts per million of fluoride in whole, entire needles.

Q What have you found on your baseline data?

A Exactly that. There are higher concentrations right in Colstrip itself, as you know, and I put that in my testimony.

Q Within a quarter-mile of town?

A They were within a mile of town.

Q With regard to what you did put in your testimony, and I'm looking now at Exhibit 233-B, which is the Colstrip site one mile southeast of Colstrip, I see where the sulfur levels on Ponderosa pine needles for the 1975 data vary from 800 to about 150. Is that a normal level?

A Pardon?

Q Is what you have represented on that chart a normal level?

A The 1100 for the 1973 vegetation is not normal.

Q Would we look at the whole needle there to get the significant value rather than the sheath or the middle of the tip?

A Right. The only thing that the tip, middle, and the sheaths are for is to show two things. First, it shows if there is a concentration of particulate in certain areas or if there is an increase in the tip of the needle, but the work was primarily done for the fluoride analysis, because fluoride doesn't translocate so rapidly in the vegetation as sulfur, and that's why we primarily separated them like this, to see how the sulfur was being translocated, and the whole needle is more realistic for true numbers for sulfur content in Ponderosa pine, and 1100 is a little high.

Q Why would you get a high reading in 1973?

A I don't know that. I can make some speculations on it, but that's about it.

Q With regard to the fluoride content of the whole needle at that same spot one mile southeast of Colstrip, that shows normal levels?

A Those are just a hair higher than normal, but they're in the ball park. Had you taken those needles without separating them, you would say that that is baseline for a pristine area. I think you'd be fairly safe in saying that.

Q How many needles were examined? Is this an average, or is this just one?

A Oh, no, no, no. What you're looking at here is all of the needles on four or five branches, separated -- well, they wouldn't all be -- I'm sorry about that. All the needles are separated from the branches, four different, five different branches, and they were then separated for the various types of analyses that we were going to carry on, and then we would take about -- they were in a big pile like this on the desk (indicating), on the worktables, and they would grab a certain percentage of them, probably take around 50 to 60 grams to dry as whole needles.

Q How many trees would that come from?

A In this particular case here, the H series, as far as H-1, H-2, H-3, these are three trees per site.

Q When were they first tagged?

A Those trees have never been tagged. These are not permanent plots. This is something that I asked Peter Rice to do for me after we had finished the Billings area, the tagged trees in Billings, to determine if I could figure out why I was getting tip burn in the area right directly around Colstrip prior to Colstrip 1 going on line. I wanted to be able to say, was this damage done prior to Colstrip 1 going on line. This is why the needles were separated into the various sections.

Q Do all of these numbers that are shown on these Series H exhibits come from the same trees each year?

A They come from three different trees at three different sites, three trees per site, three sites.

Q But you use the same three trees each year?

A I do not believe these trees were ever tagged. I have a map here if you would like to see where these trees are from around Colstrip.

Q Are these figures, then, that you have included in the exhibit averages from all of the specimens which you examined, or are they highs and lows?

A These are the readings. These are the analyses. For instance, if you look over on 1975, at the top of the page, for sulfur, the tips had 800 parts per million of sulfur in them. That is the reading, that is the analysis.

Q From all of the tips that you took?

A No, that is from the 1975 needles.

Q Right, and that would be more than one needle tip?

A I should say there would be somewhere in the neighborhood of two to three hundred needles.

Q Did you ever determine the concentration of any one tree?

A Oh, yes, many times. This is the only time that we used more than one tree for what you would call a composite sample and an analysis. What you have here is, because these trees were small, we had to denude the trees, almost, to take enough samples for what we needed to do, so we composited from three different trees, but each tree came from the exact, same location around Colstrip, and there were three locations around Colstrip.

Q Did you find any tip burn in any area further from Colstrip than just around the immediate townsite?

A Yes. I think I mentioned that we have burn around our Miles City site, and we also have burn down at our Biddle site, which is 80 miles from Colstrip. This, again, has high sulfur, around 1100, 1200 parts per million in the tips of those, and this is probably due to the burnoff of the gases from some oil wells 10 miles to the south of that.

Q Did you find any tip burn in an area approximately ten miles from Colstrip?

A Yes, we have tip burn in many areas around Colstrip. Some of that is caused by frost, some of that is caused by insects. The major damage to most of the area around Colstrip is at the basal tissue and not the tip.

Q Have you analyzed each one of the tip burn species to determine this particular cause?

A Have I analyzed each one?

Q Well, have you run an analysis?

A No, I should say not.

Q Well, then, how did you determine what the specific cause was?

A In the case of area Biddle and in the case of the Colstrip area and in the case of Miles City, these were done histologically as well as chemically.

Q Did you find any frost damage or insect damage in the area just immediately surrounding Colstrip, as opposed to fluoride and sulfur damage?

A Yes, there is insect damage around Colstrip, like there is throughout the whole area, and we have quantified the amount, the number of insects, the type of insects, and the amount of insect damage to the tagged trees at many of the sites. We're not completely done, by any means, with all the insect work and the damage work. I would say we have somewhere in the neighborhood of ten to twelve sites done now as far as insect damage to them.

Q What is the percentage of the tip burn that you found on the needles from the pine trees in and around Colstrip in relation to frost, insects, versus sulfur and fluoride?

A As we analyzed the amount of tip necrosis from our various sites, we measure the necrosis and the percentage of necrosis on those needles. Some of those needles we take and do histological work on. All of those needles, we do chemical work on, and right now, if one had to pick the amount of damage, I would say -- just from trying to think back to all the figures that we have, and I've gone over them two or three times, but we haven't got them out of the computer yet as far as total analysis -- but I would say most of the damage throughout the Colstrip area -- and I'm talking about the full 80-mile radius, or actually, 125 miles now from Colstrip -- is primarily insect damage as far as any type of necrosis or chlorosis or modeling on those needles.

Q Have you identified the insect that is causing the damage?

A In some cases, yes, we have catalogued the insect and the type of damage that they do to the pine cones, to the pine needles, and so on, yes.

Q Do I understand you to say that, for example, on Exhibit 233-D, which is the sulfur and fluoride found in the Ponderosa pine needles at the Biddle site, which is approximately 79 miles southeast of Colstrip, relative to chlorides, are you saying that for the -- well,what figure do you use to determine why these are above normal ranges on the fluoride?

A Turn to 233-F and look at the levels here from the Potomac area.

Q Where is that?

A The Potomac is 30 miles -- 25 miles north of Missoula, Montana. In this sheet, in some cases, you have a little higher fluoride in the oldest sheaths. You have an excess in the tip tissues here compared to the Potomac site.

Q Why would the Potomac site be the bellwether to compare from? Are you saying the Potomac site is normal?

A I would say it's more normal than the Biddle site, which is only ten miles from a pollution source, where the Potomac site is 25 to 30 miles from Missoula, which is also a pollution source.

Q Well, for example, now, in 1974, at the Biddle site, you found that a sheath -- your analysis showed for the sheath fluoride content of 4.3 parts per million?

A Yes.

Q At the Potomac site in 1972 and in 1973, you found the same amount, 4.3 parts per million. Why aren't they both normal?

A What site are you talking about?

Q I'm comparing the Potomac to the Biddle, as you were doing, and what I've taken is just a different year. In 1974, at the Biddle site, we have a concentration of 4.3 parts per million of fluoride.

A That's like comparing one year from another year, and what you have here is an extra year of accumulation. You've taken 1972 at Biddle --

Q That's strange, because if the accumulation is going from another year, it went down, at the Biddle site, according to your figures.

A It has less on it, the younger the needle is, because it has been exposed for lesser periods of time.

Q Right, and in 1972, those needles showed 6.7 fluoride content, and then it went down to 4.3.

A Right, because if you think about that for a minute, Mr. Peterson, you'll see that if these needles were collected in 1974, they were exposed for a matter of five months. Now, at that five months, you have to add 24 and you come up with 29 months that the 1972 needles were exposed for, and that is why you have more in the older needles than you do in the younger needles because the older needles have been exposed for a longer period of time.

Q Which are the older needles, those in '72 or those in '74?

A '72. They came out on a candle when they broke in May and June in 1972. At that time, the 1974 needles had not been conceived upon that plant, that tree.

Q Well, isn't the difference between 3.7 parts per million of fluoride in the Potomac site substantially less than the 4.3 that we find at the Biddle site in 1974?

A No, that's very close together. 3.7 and 4.3 is very, very similar.

Q Aren't those normal limits?

A Those are normal limits.

Q Well, then, what is the normal range? That's what I'm trying to get at.

A On sheaths?

Q Yes, what is the normal fluoride range? What would you call normal?

A Anywhere from two to four.

Q Would it go as high as six?

A No.

Q Did you ever testify to that effect in a lawsuit in Oregon that the normal limits for Ponderosa pine, the parts per million for fluoride would run from two to six?

A Not on that particular tissue. I have for whole needles, yes, I have.

Q Do you have any whole needle analysis for the Biddle and Potomac sites?

A No, we ran out of tissue. Sorry. Oh, I'm sorry -- we do have whole needles from Biddle, many of them, at different times of the year. I didn't put them down here because they were not collected at the same time that these are, but I do have -- in fact, they are in the study I sent into the DNRC. There would be four different chemical analyses there, two different times a year, for two years, for the Biddle area, the same trees, and everything, but not at the same time that these needles were collected for these particular chemical analyses.

Q What were those limits, do you know? Were they within two to six? For the whole needle?

A For fluoride?

Q Yes.

A It would be down around 1 to 2.5.

Q Does it make a difference as to when you pick these needles as far as the time of the year is concerned?

A There will be some fluctuation, and if you're in a pristine area, it will be a very small fluctuation. If it's in a fluoride-polluted area, it makes a great deal of difference.

Q Why?

A Because the longer the needle is exposed to that atmosphere, regardless of the concentration, as long as it is there, that fluoride is there, there will be an increase in fluoride in that vegetation.

Q Would it make any difference as to the fluoride content in the soil?

A It makes a little difference on some species of vegetation. It does not make that difference -- we have never found that difference on Ponderosa pine. We do, however, find that difference on grasses; if there are a lot of phosphate fertilizers used, there will be a slight increase in fluoride over indigenous grasses, grass species where phosphate fertilizers are not utilized.

Q Is that the reason, then, that you don't take soil samples for Ponderosa pine?

A We do take soil samples from Ponderosa pine sites; in fact, I think all of our sites have had soil samples.

Q Including these sites that you've reported in the exhibits?

A Not in the H exhibits, but all other exhibits -- I mean all other of our permanent plots. H plots were not permanent plots. The H plots were only for me to try to understand what was causing tip necrosis in the immediate vicinity of Colstrip itself. The other plots all have had soil samples taken from them.

Q On the regular sites that you have, were these soil samples taken randomly, or were they taken by the species from which you took the needles? How big are these plots?

A They vary. They can vary from a square mile all the way up to five square miles.

Q How were the soil samples taken?

A The soil samples were taken in the vicinity of the Ag spic samples and the root samples, if I'm correct. They were not taken, I don't believe, from beneath the Ponderosa pine, but I can clarify this as far as the fluoride uptake, and maybe that will be the fastest way to solve this problem. I have worked in fluoride areas, and I've had farmers take soil samples from their farms, transplant it outside of the impact area and grow the same vegetation upon that,sow their soils, in little plots, as they have growing on their fields in the impact area. We find that we do not have an increase of fluoride in the vegetation growing on soils with excessive fluorides in them. The fluoride is simply not taken up that much. It's a very small amount of fluoride that's taken up in vegetation.

Q As far as the Ponderosa pine is concerned, then what you're saying is that they don't have very much of a takeup of fluoride from the soil?

A That is absolutely true.

Q What about the grasses? What about Western wheatgrass, or whatever it is down there, the dominant grass?

A They'll vary. Some species will have a little more than others, but most of the dominant ones, the Western wheatgrass and Ag spic, I think it's 2 to 4 -- 2 to 5 -- right in that area, right there.

Q What is the effect on the tree as far as the fluoride content is concerned, if I, for example, find one tree here which you say is normal, at Potomac, at 3.7 on the sheet, and the tree at the Billings Heights site at GB-2 is 7.6? What effect does that have on the tree?

A This is primarily what we're determining now. It's the sheath that we're really terribly concerned with here, because the sheath is dead tissue. It's sclerenchymatous cells, which die very early during the early morphogenesis of the needle, and any fluoride or sulfur compounds are not within that tissue, but on the outside, and this is probably particulate. What we're determining is the solubility of that fluoride and sulfur compounds to determine if that's where some of the acids are coming from that cause the burnout of the basal tissues, the live basal tissues of the needle per se. You see, the sheath is a dead tissue. It's nothing more than a protective layer during the early morphogenesis of the needle. Now it's dead when you see it there, and in some species, of conifers, is cast, like in the White pine --that fascicular sheath is cast -- not so, on many other pine species. What's interesting about that increase in sulfur and fluorides in those sheaths is that that is where much of the -- I'm hypothesizing -- is that much of the damage is being caused in causing the basal burn.

Q Other than basal burn, what does that have to do with yields, height, and so forth?

A It has everything to do with it. It's like going out and stripping different year's needles off of a tree. If the needles are cast from that tree, then there is less food-producing area on that tree and you have less annual growth. It is just like what happens after a heavy frost -- you'll lose the current year's needles from a heavy frost. That frost will show up in damage to annual growth to that conifer. You would be able to read that loss many years hence.

Q How much casting did you find in the Billings Heights GB-2?

A One second, please

Q That's at 233-E. That was my reference in asking the question. You may have some other data.

A I believe it's 225 when you're dealing with Billings Heights GB-2. No, it's not.

Q I only saw GB-1.

A I can put this into evidence if you'd like. It's from my progress reports to EPA. I put in four sites in this report to EPA. Again, as I said, all of this data has not been put into the computer. It makes it much easier after it gets into the computer, because there's so much data here, but let me give you an example here. I'll use GB-2 site and I'll compare it to our site south of 5, which is Poker Jim site, which is down by the Howe Ranger Station in the Custer National Forest. The needle retention for 1975 needles is 98% at GB-2, the Billings Heights -- I'm just saying approximately, from the ground -- the 1974 --

Q 98%?

A Ninety-eight percentile. The 1974 needles has about a 91 percentile needle retention. The 1973 needles had a approximately 55% needle retention, and the 1972 needles had a 70% needle retention. Okay, if you compare that with our South 5 site at Poker Jim, the 1975 needles had a 99% needle retention, the '74 needles had a 98% needle retention, the '73 needles had a 92% needle retention, and the 1972 needles had an 80% needle retention. Probably what is more important, however, is the percent of those needles being retained which are without sclerosis, necrosis, modeling, basal tissue damage, insect puncture wounds, and this type of thing.

Q Would you consider the retention figures which you just gave for the site near Custer to be within normal ranges? If not, why?

A It's fairly close, as far as talking about Poker Jim site?

Q Yes.

A It's a good site on the Custer National Forest. I have other data that shows that it is not the very best site, but by no means, is it the very worst site within the sites that we have around Colstrip.

Q Why would the Billings Heights site at GB-2 have a needle retention of 98% in 1975?

A Because the needles had only been out about five months from the time that they had been -- had appeared to the ambient air. They had not been exposed to the phytotoxic gases of the Corette plant and the refineries for more than that period of time; therefore, they had only been assaulted for that 5-months period.

Q Do you gather that needle retention data on an annual basis?

A I'm not following that.

Q Do you gather that data on an annual basis?

A No, this data was gathered -- all of our needle retention work was gathered during 1975. It's a very, very time-consuming job. It took thousands and thousands of man-hours this last summer to carry out those studies.

Q Is there some data with which you work which would give us an indication as to what would be the average retention for needles in a pristine area over the last five years?

A Yes.

Q Do you think Poker Jim would be close to that?

A I think Poker Jim as far as -- it is a pristine area. We have not done all of the analyses that we are going to be doing on Poker Jim vegetation. We are doing precipitation chemistry there, instantaneous collections -- or events, I should say -- sulfur, fluoride, and of course, the examination of many hundreds and hundreds and hundreds of needles from the vegetation there.

Q Who participated in this needle retention work analysis?

A Most of the people hired were graduate students. There were also U. S. Forest Service personnel, who were doing the same work for Addy, the Addy plant, the magnesium plant over by Colville, Washington -- they took some of the plots. We have two trailers down at Whitetail Ranger Station. At that ranger station this summer, we had 3 -- 4 -- 5 people -- I guess five people were there. Do you want their names?

A Just give me their educational background, basically.

A Bob Boldi, who's sitting behind you, is a graduate from Boston

University, now in the Environmental Studies Program. Pat Meinhart is a biology student, senior, last-quarter senior. She worked there. There was a person who had worked for the Forest Service -- I can't even remember his name right now, Don Burke, right -- and he was four or five years with the Forest Service. He's a biology school teacher at Sentinel High School in Missoula, Montana. Peter Rice was there. He's a graduate in biology from the University of Montana. There was Rod Daniels, a biology student, a former biology student at the University of Montana. I think that's all.

Q What kind of methodology do they use, or method do they employ to estimate the needle retention?

A The branches are cut. This happens in the field. For each tree that is permanently tagged in the field, five trees, young trees, five trees, older trees, the upper crown and lower crown, four branches from each crown, the upper crown and the lower crown. Then, immediately in the field, ten needles of each branch and each year's growth -- you might have five years internodes that you'd be selecting ten needles from -- these are put into coolers with dry ice right in the field, and this is what we do with our chlorophyll analysis later on out in the lab. They're put in separate bags and tagged and taken back to the Whitetail Ranger Station, where they are observed very carefully as far as needle retention. They count where the needles have been cast for each internode, year's internode. After they have done that, they select a hundred needles -- all the needles are stripped from the branches and in a big pile, and they select a hundred needles from each year's growth. If you had five different years' growth, from four branches, you'd have '75 yield, '74, '73, '72 and '71 needles, then a hundred needles from each of those inspected for necrosis, chlorosis, the amount of insect damage, and if they find anything particularly interesting, they prepare it for histological study by me at the lab or by the Forest Service. They measure the diameter of the needles, a cross-section of the diameter of the needles -- I think 20 needles from each crown, something like that. It's very meticulous, very carefully done work.

Q How many sites did you take, did you work on, for this needle retention work?

A I believe we finished 17 sites. We personally did 17 sites, and Bromenschenk, Dr. Bromenschenk, has done eight sites, I believe, so collectively, we've done 25 sites.

Q How many of those were in what we would call a pristine area of the 25?

A I would say approximately 15 or 16 of those were pristine sites. They included two sites in North Dakota, one site in Wyoming, and the rest of the sites were in Custer except for one site we have on the Northern Cheyenne and a couple real close to Colstrip, and two sites in Billings.

Q How close were the sites in or about Colstrip?

A I believe the closest site is on Red Kluver's land, which would be about three miles from Colstrip.

Q Do you consider that a pristine site?

A It was prior to September 1975.

Q Have you been back on that site since September 1975?

A No, I have not.

Q Do you intend to take a needle retention estimate on that site next year?

A We will take needle retention on every single site we did this year and we will increase the number of trees from 10 to 20 for a better sample size.

Q What was the other Colstrip site other than the Kluver property?

A I think it's on Wally McRae's land, but I'm not sure. Peter is nodding to me yes, so I'm sure now.

Q Were the sites you selected, selected solely by yourself?

A Most of the Forest Service sites were selected by Clint Carlson, myself -- in a about a 2½ to 3-week period.

Q Who selected the sites on the Northern Cheyenne Reservation?

A That site was selected by -- originally, the first three -- and this morning, I said I didn't know whether there were two or three -- that one over on the southwest actually is on the Northern Cheyenne, so there are three sites on the reservation -- those sites were selected by me from maps, and Kay went out and set them up, and the Northern Cheyenne sites for this year, the Morning Star site, was set up by Phil Tourangeau.

Q When you say this year, you mean 1975 and 1976?

A 1975, right.

Q What were the readings on the site relative to needle retention on the Northern Cheyenne Indian Reservation?

A I don't know if I have the Morning Star site.

Q Do you remember whether or not you considered it to be within normal range?

A Yes, it was a good site. There was insect damage there.

Q Were any of these sites located near the logging activities of the Ashland Lumber Company or the Black Lumber Company?

A No, they're up on top of the ridge. They're not so very far. If any one of those sawmills put out anything that was phytotoxic to vegetation, such as a pulp mill or a coal-fired power plant, they would have been damaged, but these plants are not being damaged by the emissions of a wigwam burner.

Q How about the emissions from any logging trucks?

A I figured that out once upon a time, how many cars it would take to put out as much garbage as the East Helena smelter, and I think we had to drive most of the cars in the United States through East Helena to get the same amount of pollution. I forget the exact figures. I have them down in the office. You won't get that type of damage from trucks.

Q Would you give me the percent that you consider to be within the normal range of needle retention in a pristine area, from one year to the next?

A Well, you should have 98 to 100 percent needle retention for both the current year needles and the 12 to 14 or 18 months needles, to be in that area, the 98 percentile and better on needle retention. It will fall down into the neighborhood of 90 to 95 percentile for the third year needles, and the fourth year needles fall into the 80 percentile, and for the fifth year needles, you'd be somewhere close to that. Of course, this is totally dependent upon insect, fungi, frost, and also one other thing, and that is, is there such a thing as a pristine area anywhere in the United States, and I don't believe there really is such a thing, but Colstrip comes as close as any place we've been.

Q What is the average, then, for needle retention, about five years?

A It depends. We didn't bother going back any farther than five years in the Colstrip area, but there were needles there that were being retained up to seven years.

Q What would be the percentage of retention, for example, for seven years?

A I don't know that, we didn't do it, but I would imagine it's in the 40 percentile, the 30 percentile down in that area there.

Q How about for the six year?

A They were there, but they would be a little better than the previous, the older year, the seventh year. You know, in areas where you have pollution, the needles are cast almost simultaneously, the older needles, when they are cast, when they get really old like that. You just don't find them. They don't cast uniformly in a pristine area like that.

Q If you had an area, then, of heavy pollution, you wouldn't expect to find any needles past the sixth or seventh year that hadn't been cast?

A Once in a great while you will. You'll find in Billings, primarily around four years, you will find once in a while what you might call phloemducity or escape needles that don't have quite the needle burnout of the basal tissue and you can find -- I think I've found up to six years needles in the Billings area -- not many of them, but we did not do any percentage needle retention on those.

Q You mentioned the plant around East Helena. Have you done any needle retention work in that area?

A Only to those trees that I planted in the East Helena area in 1968 when I was working for the Department of Health and Environmental Sciences.

Q But you didn't take any survey of needle retention of a particular plot?

A No, we did not do it in that way. The way we tell how many years' needles we have in those areas is when we go and take the needles from -- we take the branches and we bring them back to the lab, and we take the needles from the branches. We know how much it takes to make a sample for chemical analysis. It's usually around 50 grams, and this way you can tell pretty much the needle retention. If you go back and say, you have four or five bottles for that particular tree, that's where you have four or five years' needles. We would have taken all of them in the East Helena area. You'll find in the East Helena area, we only have samples for four and sometimes five years' needle retention.

Q You've never seen any pine trees in this area in East Helena which had longer retention than five years?

A Yes.

Q Have there been some?

A Oh, yes.

Q For how long, what year retention, six, seven?

A At least six, and I would probably say some sevens.

Q Have you got any beyond seven?

A No, not that I can remember.

Q Regarding other species, Dr. Gordon, that you worked with in southeastern Montana, as I read your statement on page 7, you say that you are working with a rather small number of plant species, approximately 40 to 50. How many actual plant species would you say there are, totally, in the ecosystem of that area?

A Of the Fort Union Basin?

Q Yes.

A How many fungi and insects? Or do you mean just plants?

Q Plants.

A Which are also fungi.

Q Just higher species.

A Literally, several thousand plant species.

Q And out of that 40 or 50 that you're working with, you're concentrating on eight, is that right?

A That is correct.

Q And out of that eight, you're concentrating very heavily on one, the Ponderosa pine?

A No, that is not correct.

Q Out of that eight, you consider Ponderosa pine to be the most susceptible of all of the other eight?

A Of the eight that we are working with, yes, I expect the Ponderosa pine to be the most susceptible; however, there are more susceptible species in the Fort Union Basin. There is a scientist working with us from Bozeman. Her name is Sharon Eversman. She is working with lichens, and she shows much more susceptibility to the damage than Ponderosa pine.

Q Are you working with any juniper species?

A Yes, we are working on junipers.

Q Is that Rocky Mountain juniper more or less susceptible than Ponderosa pine?

A This was one of the questions that was asked Dr. Edmonds the other day.

Q What's your answer to that question?

A My answer is that juniper is much more resistant to sulfur than Ponderosa pine.

Q What data do you base that conclusion on?

A I base that on our studies around the East Helena smelter. I base it upon our studies around the Anaconda smelter, and also a study -- it's not Rocky Mountain juniper, it's eastern juniper, on Long Island, New York. Juniper is really very resistant to most pollutants.

Q What data did you collect in order to make the comparison between juniper and the Ponderosa pine?

A Primarily, the necrosis and the sulfur content.

Q In other words, you compared sulfur content of the two species in the area of Anaconda and East Helena?

A Right.

Q Were you able to determine the respective ages of the trees, compare the age?

A No. They were composite samples. As far as the vegetation on the juniper, we do not separate the different years' scales from the former year's scales.

Q What did the data show as to concentration levels?

A The concentration shows that there are higher sulfur concentrations in the junipers at the same locations than for Ponderosa pine.

Q Do you remember the level?

A No, I don't remember the levels.

Q Have you presented that in a report to EPA, or for whom were you doing this work?

A I did the work for East Helena for the Department of Health and Environmental Science and also for EPA, NAPCA, the National Air Pollution Control Agency, and the study on juniper we did for ourselves.

Q Do you have the data available as to the levels of concentration in the respective species?

A Not with me here.

Q I understand that, but I wonder if you could provide that to me when you go back?

A Yes.

Q What phytotoxic gases is Ponderosa pine most susceptible to?

A Fluorides. There are some who will argue that ozone -- that it's very susceptible to ozone, too, but as far as concentrations, a given concentration, fluorides are by far the most phytotoxic gas to Ponderosa pine.

Q You don't think that it's more susceptible to higher concentrations of ozone?

A If you have Ponderosa pine in an atmosphere of a tenth of a part per billion, you can have damage to that Ponderosa pine. It takes approximately 80 parts per billion to cause some damage to Ponderosa pine. In the area of the San Bernardino Mountains, the concentrations are around 10 parts per hundred million up to twenty parts per hundred million, to cause damage to Ponderosa pine.

Q From ozone?

A From ozone, but unfortunately, they don't read anything but ozone, nor do they do sulfur analysis or fluoride analysis, which are also present in the San Bernardino Mountains.

Q Have you seen any ozone damage on the Ponderosa pine species in and around Colstrip?

A Not at this time, I have not.

Q Have you made any analysis for ozone damage?

A Yes, I have.

Q And what did you do?

A Ozone is determined primarily from histological -- in fact, it is the only way. You cannot carry out chemical analysis for ozone. Ozone has a fingerprint that is unlike any other type of phytotoxic we've ever worked with, quite unlike, also, frost damage and so on.

Q You don't have an ozone sample attached to your Exhibit 240, do you?

A No, I do not.

Q In your studies and work, have you ever been able to demonstrate that Ponderosa pine developing needles have been injured by fly ash?

A In the winter of 1971-'72, I carried out a fly ash experiment on Ponderosa pine, Scotch pine, and White pine. Fly ash caused some damage to the White pine, a little to the Scotch pine -- I do not recall its causing too much damage to the Ponderosa pine. Of course, I was using much more -- more of my samples were Scotch pine than any other species.

Q As I understand it, in reading one of the exhibits that you've attached to your statement, by you and Mr. Tourangeau, with regard to the fly ash treatment and study, you state that when the candle stages of all three species of pine were innoculated daily for up to 30 days with dry powdered fly ash and bottom ash, symptoms of the short-long needle syndrome were not found?

A That is right.

Q And that slurry fly ash and bottom ash, when applied to the foliage of the candle stages of all three species of the pine failed to produce the short-long needle syndrome in 10 to 20 days' period of innoculation, but occasionally did produce excessive budding on both the Scotch and White pine?

A Right.

Q How do you signify or determine that excessive budding is damaging to a tree?

A In the particular case that we were working with there, the excessive budding is on a horticultural species that are trained with some delicacy for a tree to grow perfectly for people who like to buy perfect Christmas trees, and that excessive budding was not preferred by those people who buy these perfect Christmas trees.

Q Your advice to the Christmas tree growers now has been to go to aluminum, hasn't it?

A To buy aluminum trees?

Q Yes.

A I did suggest that once.

Q This study with the fly ash, Dr. Gordon, was this simply a method of painting the slurries with a brush onto the foliage?

A That is correct. The thing is, what you've previously said, and I think it should be straightened out, and that is, you can have damage to a young, developing needle without it being a short-long needle syndrome. That was the specific syndrome I was going after. That fly ash, however, can cause damage other than short-long needle. It can cause chlorosis and necrosis of those needles. What I was locking for in those days was what was causing the short-long needles throughout the Mount Storm area of West Virginia and Maryland and also into Pennsylvania.

Q Well, did you report the finding of any damage from the fly ash slurry as far as necrosis was concerned?

A No, I did not report it during any of my work there, because that was not what I was after, chlorosis or necrosis, I was after the short-long needle syndrome. I was trying to duplicate what was happening in the field.

Q Why did you then report about excessive budding if you were just simply interested in the short-long needle syndrome?

A Because one of the abnormalities -- that's an abnormality -- and one of the things -- one of the abnormalities that the farmers were complaining about, the Christmas tree growers, was the excessive budding and the lack of budding, as well as kinked needles and the short-long needles. It was one of those growth abnormalities that I was working with. It was not the one I was attempting to do or to get in the greenhouse or out in the botany garden. What I was really after was the short-long needle syndrome, which was the major problem of those three growth abnormalities.

Q But you did report from that same experiment or study in your greenhouse that alkali solutions could produce needle necrosis. Why did you make reference to that if you were just looking at the short-long needle syndrome?

A I think I was just reporting an observation on a treatment that had no other observation. The alkaline materials simply didn't work for the short-long needle.

Q Why didn't you then report the necrosis for the other observation dealing with the fly ash if, in fact, it did occur?

A I guess I just didn't think enough about it to report it. I will say this, though, that all of the trees that were innoculated by the various methods were also photographed at the end, in color, and all of those photographs are available in the environmental studies photography library.

Q Do you anticipate that the method in which you applied the fly ash to the foliage in your greenhouse study would indicate what's going to happen in and around Colstrip?

A No, no, I don't believe that at all. I think the fly ash will cause many problems, but it won't cause problems to -- the application will not be the same in the field as I put it on there in the greenhouse. Those were very heavy applications. The primary problem with the fly ash, as far as the conifers are concerned, will be that portion of the fly ash which is soluble and will form sulfuric acid and hydrofluoric acid in the basal tissues of the needles.

Q Dr. Gordon, in your statement you make reference that during the last six years, you had an opportunity to do studies around coal-fired plants located in three different areas, Mount Storm, West Virginia, and Maryland, Paducah, Kentucky, and Billings, Montana. When did you first begin the work at Mount Storm?

A In November of 1969.

Q Was that with EPA?

A I was asked to come back there and be a consultant for EPA.

Q Did you prepare any kind of a report for EPA as to whether or not there was damage from any air pollution source?

A During the early part of '69-'70, I wrote a few reports, giving my opinion, from the few times I'd been there, and so on. In 1971, there was an abatement hearing in Keyser, West Virginia. I worked in Mount Storm again during '70, October and November of 1970. From '69 until 1973, I think I probably wrote at least ten reports which I sent to EPA. Some of these are progress reports and so on.

Q In the beginning of the reports, I think you've testified and so written that the necrosis that could be seen from the foliage of the pine trees was caused by excessive concentrations of sulfur dioxide. That was your first position, was it not?

A If that dealt with the Steyer Home Plantation or Steyer 2, as it was then -- I don't know which plantation you're talking about -- but in general I can remember enough to say that I did talk about sulfur dioxide extensively during the Mount Storm studies.

Q And I think you've testified at the Mount Storm trials dealing with the Allegany Power case, didn't you?

A Yes, I did.

Q Did you give testimony at that time that you did have a change of mind as to the cause of the damage?

A I can refresh your memory, if you'd like, how that went. One of the questions asked was why I no longer mentioned fluoride in the Mount Storm area. During my earlier reports, I talked about fluoride, as well as sulfur damage, and I said very candidly and openly at the Federal Court hearing trial in front of Judge Miller in Baltimore in the early spring of 1974, that I dropped my allegations against fluoride because I was told that if fluoride was not a major problem in the Mount Storm area that you should leave it alone so "we can give you a contract to study sulfur damage in the area of Mount Storm." I said that very openly and candidly to the judge and to the cross-examination; therefore, Mr. Summerville, the lawyer for the Monongahela-Allegany said that I sold out for the $16,000 moneys that I got to study Mount Storm from EPA. I'll say this, and I think it should be clarified. Dr. Winestein likes to bring it up and so on that I sold out very cheaply for $16,000. The federal government has not set a fluoride standard. It has no criteria document for fluorides. They did not want to deal with fluorides. They wanted to deal with something that they could have a handle on such as sulfur dioxide, which they have a criteria for. They did not deal with fluorides. They have never dealt with fluorides. I deal with fluorides. I never stopped carrying out analyses on fluorides on the vegetation in Mount Storm even after I got this -- or before I got the $16,000 grant, so we do know that the fluoride contents were in that area. I simply left it out for a while, but then came back to it when I started sending in quarterly reports to the EPA people. I started putting fluorides back into my data again.

Q Well, I think the testimony was that, according to the transcript that I read --

MR. SHENKER: Just a minute -- if you have a transcript, let's get it out --

MR. PETERSON: We'll get it out.

MR. SHENKER: Okay, let's do that.

Q Didn't you testify that you were backing away -- this would be about 1971 -- you were backing away at this time because you wanted to work in Garrett County around the power plant "because I had never worked around a power plant and so I went along with EPA and backed away from fluoride, but I'm no longer working for EPA in the Garrett County area." Isn't that basically what you testified to?

MR. SHENKER: I'll object to the question. It's not basically what he testified to. If we have a transcript, we should see it.

HEARINGS EXAMINER: If he can recall, or if he wants to refer to the transcript first, that would be fine. He might know right off the top of his head.

A I think that's fairly accurate. I think it should be pointed out that that is a very small portion of the testimony. I testified for 3½ days in that Federal Court and therefore, that would be taken out of context, because I did talk about the fluoride damage in the area to Judge Miller. It was a no-jury trial -- just the judge.

Q After you had changed your mind and you went back in and decided there was going to be SO_2 damage together with fluorides, you were working for somebody else other than EPA at that time, weren't you?

A No. I only worked for EPA in the Garrett County -- and except for the times that I testified, for the farmers. At all other times, I was being paid to do my work and studies by the Environmental Protection Agency.

Q When did you first make a report to EPA that there was fluoride damage caused by those power plants?

A I think it was in -- it was prior to the Keyser, West Virginia abatement hearing, which occurred in the spring of '71, so it would be during 1970.

Q Was EPA interested in that new analysis?

A Absolutely not.

Q What was the amount of the pollutants that were spewing out of the Mount Storm area as far as sulfur dioxide is concerned?

A About 120,000 tons a year.

Q For the one plant?

A It was a 1160 megawatt power plant at that time, a coal-fired power plant, going to 1600 megawatts in 1974 -- it went to a 1600 megawattage in late '73 -- no, early '74.

Q Was there a report in the abatement hearing as to the total number of tons that were being placed in the area by the power plants?

A All of the power plants?

Q Yes.

A No. Only I have extrapolated that from depositions and testimonies from the companies in the lawsuits by the plaintiffs there.

Q And you extrapolated a figure something like 788,000 tons?

A That is correct.

Q What were the fluoride emissions, based on this same extrapolation?

A

A I think I only did fluoride emissions from the Virginia Electric Power Company. I can't remember if we did extrapolations from the Court Martin, the Allbright, and one other plant -- I can't even think of it right now. They were all about 50 miles away except the Allbright plant was only 20 miles from the Christmas tree plantation.

Q What did you use as far as fluoride emissions were concerned?

A I used the bottom ash, the fly ash, and the coal.

Q Do you know how many tons you computed?

A I think it's something like 800 and some pounds a day, as I recollect.

Q At the same time that this damage was occurring in the Mount Storm area, Dr. Gordon, did you happen to make any inquiry as to what effect the fly ash had upon the Ponderosa pine -- or not the Ponderosa pine, the white Scotch pine?

A I did carry out studies on Scotch pine as far as fly ash is concerned, yes.

Q Was there a problem that the Virginia Electric Power Company had with their precipitator?

A They had lots of trouble with their precipitator. Sometimes it would not run at all and they would put out 60 tons of fly ash an hour. They now have the largest electrostatic precipitator on any coal-fired power plant in the world, which runs very efficiently.

Q What is their efficiency of removal at this time?

A 99.8%.

Q Have you been back to the area since that precipitator was put on line?

A No. I have a picture of it and I also have vegetation from this year - last year's growth.

Q You wrote, did you not, after your study you wrote in 1972, in November '72, that in the future it's going to be impossible to grow and cultivate trees -- species of conifers -- White, Scotch and Virginia pines, in healthy conditions in the Mount Storm area?

A That is correct.

Q And you further concluded, did you not, that this problem will persist until adequate abatement equipment is installed at large stationary emission sources of sulfur dioxide, fluoride and particulate matter in the entire region where Christmas tree plantations producing these species are located?

A That is true.

Q Did you find acute damage at the Mount Storm area or chronic?

A I found both.

Q Was there evidence presented at the abatement hearing in which I guess you also found that there were occasions, for example, on September 12, 1970, when it appeared that the plume was trapped in a limited mixing depth condition and much of the Stoney site was beneath the plume and subjected to sulfur dioxide levels as great as .36 parts per million on an hourly average?

A That is not my data. That is EPA's data.

Q You don't have any reason to disagree with that, do you?

A No, I do not.

Q And you further reported that at the plume centerline, the hourly values were greater than .48 parts per million, but they couldn't measure it any greater because the monitoring station would not go beyond that point. Do you remember that?

A Yes.

MR. PETERSON: Shall we take a break, Mr. Davis?

HEARINGS EXAMINER: Let's take a recess -- about ten minutes.

(HEARING RECESSED AT 2:52 P.M.)

The hearing was reconvened at 3:15 P.M., following a brief recess.

HEARINGS EXAMINER: I just talked with Mr. Hadden, attorney for the Environmental Defense Fund in Denver. He will have one witness, who will talk on pricing alternatives and capital investments and so forth, as it effects demand, I assume. He can be here next week, and so I scheduled him for 9:00 o'clock next Tuesday. In talking with counsel, in your absence, Arden, they advised that they will not be prepared to cross-examine your witness, Mr. Tourangeau, or the Northern Plains witness, Mr. Johnson, and what I would like to do is then schedule them for next Monday, starting at 1:30. In that way, we could conclude your witnesses; then, Tuesday morning, we could finish the Environmental Defense Fund, and Tuesday afternoon, I'll try to pass the word for any and all public witnesses who want to come in and we'll finish up all the cases in chief. I want to hear comments from everyone on that schedule and see if it will work with everyone's schedule. Then I would recess until the following week and start rebuttal. In other words, we'd be going through the case in chief, as I visualize it. Our last witness would be some time Tuesday and then we'd recess until the following Monday or Tuesday, whenever the Applicants can get their rebuttal witnesses scheduled, and we'll start our rebuttal then. That would be the week of the 22nd.

MR. SHENKER: My only problem with that schedule, Carl, is that of course, Mr. Tourangeau is here now. We'd be prepared to stay whatever time is necessary; you know, today, tomorrow, Wednesday, to take Mr. Tourangeau on cross-examination, but for us to come back for half a day on Monday of next week -- and that's it -- because Tuesday is Environmental Defense Fund and we don't have any cross-examination there, and that half a day for a whole week is not an economic use of time, it seems to me. I would make one of two suggestions, either that we finish our case in chief now -- we're here -- our witnesses are available, or to have our witnesses come back when we have to come back anyway, just prior to the commencement of the rebuttal case.

HEARINGS EXAMINER: The only problem I have with that is regarding what happened at the end of last year, when you were going to have rebuttal. You took the position that you couldn't prepare rebuttal until you knew what they were going to testify to, until they got through with their testimony.

MR. SHENKER: Well, the only problem they'd have, of course, would be with Mr. Tourangeau. They'd know every other witness, and of course, Mr. Tourangeau's direct testimony they've had now, since last Tuesday, so they don't have a question in terms of rebuttal as to his direct testimony. The only possible area would be cross-examination, raising issues on their minds, for rebuttal, which is a fairly narrow kind of area, and it's different, of course, than not having prepared written statements in direct examination, which is the case, as I understand it, in rebuttal. You don't know what a rebuttal witness is going to say until he says it, if you don't have the direct prepared, written statement in advance, so in any event, either way is okay with me, whether we come back and take Mr. Tourangeau immediately prior to the commencement of the rebuttal case, or we stay now to take Mr. Tourangeau whenever we can plead it this week, but I would be distressed at having to come back Monday for half a day, round trip both ways, time here and time in transit for just a half a day of work for that week.

HEARINGS EXAMINER: Mr. Peterson.

MR. PETERSON: I don't have any objection having

Mr. Tourangeau, taking him, when they return for rebuttal.

HEARINGS EXAMINER: What's your position as far as Mr. Johnson's testimony is concerned?

MR. PETERSON: We just got it at 1:00 o'clock Friday. It goes into the depth of the rate case and I don't know anything about the rate case. They want to put him on tomorrow, I understand. He's got computations in there relative to base, and whatever. We're having it examined today by some rate people. We just won't be ready for him tomorrow, that's all.

HEARINGS EXAMINER: Then in that event, I'm wondering about a week from today. That would be Monday -- if there's any point in reconvening Monday and just reconvening Tuesday and take the Environmental Defense Fund and Mr. Johnson then and any public witnesses that want to come.

MR. PETERSON: That's fine.

HEARINGS EXAMINER: So that you can notify Mr. Johnson, Mr. Graybill will be here tomorrow, when he can put any input he wants to into the record in regard to this, but you can advise him I am inclined to go along with that schedule because of the time factor involved on the service and notice. I'm also not unmindful of the fact that Mr. Tourangeau has had plenty of time to get his statement in and alleviate this whole thing. I don't see anything in his statement that had to wait until after these other witnesses testified, to prepare, as I had assumed was the reason, so if they're agreeable to doing it that way, that's fine.

MR. SHENKER: Have you ever read a computer analysis? It's a very time-consuming task.

HEARINGS EXAMINER: Well, he's had a year to do it. That's when we finished discovery last year for this case, the 20th of April or May, when we announced we were ready to start.

MR. SHENKER: Well, I just wanted to make the point, Carl, since we're on the record and you took a whack at our witness. I wanted to make it clear that the reason it took so long is that he took relatively recent data. He didn't take 1974 data; he took 1975 and 1976 data, put it into a computer analysis, and that doesn't get done overnight.

HEARINGS EXAMINER: Well, it doesn't get done while you're up here at this hearing, either, and he's been present a lot of the time. I know what your problems are, but I --

MR. SHENKER: That's when other folks were working on the computers back there.

HEARINGS EXAMINER: I see. Okay, we've got that worked out to everybody's satisfaction. You won't have to make a fruitless trip, Mr. Shenker, and I'm very happy to see your concern about the economies of scale, as I am, in these proceedings.

MR. SHENKER: I'm delighted with your happiness as to my elation.

HEARINGS EXAMINER: All right, we'll continue with the cross-examination. If we don't get through with this witness, we'll continue with this witness tomorrow. Is that all right, Dr. Gordon? Is your schedule flexible in that regard?

WITNESS: Yes, it is.

MR. SHENKER: Will I tell Dr. Tsao that I assume that he's to come back tomorrow to finish his cross-examination, or is there nothing more that you want to ask him?

HEARINGS EXAMINER: We can take him that following week, if we need to, I suppose.

MR. PETERSON: I don't need him.

HEARINGS EXAMINER: Are there any other loose ends that we should mention while we're on the subject so we can all plan ahead?

MR. SHENKER: Shall we take up the depositions tomorrow when we finish with Dr. Gordon?

HEARINGS EXAMINER: If we have some Northern Plains live witnesses, if you're going to be here to catch the evening plane, I assume if we couldn't take them and further confuse the order, but get rid of the live witnesses and then take it up if we could?

MR. SHENKER: Fine.

HEARINGS EXAMINER: I understand they don't anticipate lengthy cross on the live witnesses, and if Mr. Johnson is not going to be here, we won't have that many of them.

MR. SHENKER: May I ask, Carl, since it looks like tomorrow will be my departure time and we're not coming back until rebuttal time itself, when are we going to know who the rebuttal witnesses are?

MR. PETERSON: You will be given statements at least three days before they even testify. We may be in a position tomorrow to give you some names of people.

HEARINGS EXAMINER: I guess that everyone has observed in the order I made that it required three days' notice to have written statements on rebuttal, as well, and apparently we're proceeding along that line. Does anyone object to that? (No response.) Kit, did you have anything for Northern Plains?

MR. MUELLER: I'm just curious as to whether Northern Cheyenne is going to finish up on Wednesday.

HEARINGS EXAMINER: Yes. Then we're going to continue to Wednesday and finish up the Northern Cheyennes' case, plus if there are any public witnesses who want to come in tomorrow afternoon. That way we could accommodate quite a few public witnesses Wednesday, I'm sure. Very well, if everybody is ready, let's proceed with the cross.

CONTINUATION OF EXAMINATION OF DR. C. C. (CLANCY) GORDON

Cross, by Applicants

By Mr. Peterson (Continuing):

Q Dr. Gordon, with regard to the Mount Storm area, would you say that the topography and the climate of Mount Storm and Colstrip are comparable?

A In a way. The topography and the climate and meteorological conditions are definitely not comparable, but the topography is a flat to a rolling terrain. As you know, it's on the top of the Appalachian Ridge there, and it is mountainous and there are lots of draws, very similar -- well,not very similar, but somewhat similar to the area in Colstrip.

Q Are there a lot of peaks and valleys in and around the Mount Storm area?

A Yes, there are.

Q Are they as significant at Colstrip as they are at Mount Storm?

A Oh, yes.

Q Now, as I understand it, one of the events that took place back there that you examined was associated with Hurricane Agnes, according to one of the reports that I read?

A That is correct.

Q And you make note in the trip report that the winds of Hurricane Agnes carried the effluents from the Vepco power plant, quote, at ground levels, for several miles, unquote. Is that right?

A That is correct.

Q That's in your Exhibit 223?

A That is correct.

Q What was the predominant wind direction and speed of the wind associated with that hurricane?

A The predominant wind was coming out of the southwest, pushing towards the northeast.

Q How about wind speed?

A I do not have the wind speeds at Mount Storm per se. In my trip report, I talk about the fact that those wind speeds are from the Morgantown airport.

Q What numbers were they?

A Thirty-five miles an hour.

Q Was vegetation damage equally distributed on the mountaintops and mountainsides and the valleys downwind of the plant?

A No, they were not.

Q Was it more or less pocketed?

A It pocketed after it got out about four or five miles, but as far as the first mile and a half, two miles, it took a wide swath, but it would come up over the top of the mountain and then miss the valley below and then hit the top of the next mountain.

Q Was the vegetation damage concentrated on the windward side of the mountaintops?

A Right, that is correct.

Q Well, then, what I don't understand is when you make the report stating that winds of the hurricane carried the effluents from the Vetco plant at ground levels for several miles. Wouldn't the sides of the hills and the valley floors also be equally affected by the effluents as well as the tops, or were they?

A No, the valley floors were not affected like the tops of the mountains.

Q Did you find any damage at the valley floors?

A Very little. We talk about that in my trip report at a place called Sherr -- S-h-e-r-r -- I believe.

Q What did you mean, then, by the term, at ground level?

A At ground level at the tops of those mountains.

Q I see. How many days did the fumigation that you say occurred associated with Hurricane Agnes?

A We don't know how long it was, but it could not have been longer than a period of more than three days, two to three days. It probably was much less, but the damage didn't start showing until the fourth or fifth day. The winds were strong, I believe, for two to three days, during that period of time.

Q Did you distinguish the sulfur dioxide damage from the other types of vegetation damage?

A There was quite a bit of wind damage, too, and I did distinguish that in my report.

Q Did you conduct all these examinations when you went to Mount Storm in July of 1972?

A The majority of them. I also brought vegetation back to the laboratory and also broad leaves, deciduous plants and conifers.

Q What are the characteristics that one would find, as a plant pathologist, between SO_2 damage and wind or frost damage?

A In the case of the wind damage, you'd have a shattering or splitting of leaves, which you did find in some areas there in the Mount Storm area after Agnes. You find loose needles in the fascicles. The needles are pulled directly out of the fascicles. I mentioned that in my report.

Q Is that from SO_2?

A That was primarily from the fact that the basal tissues had already been burned out from these needles. These were previous years' needles, and then, if you want to talk about frost damage, the frost damage on coniferous vegetation would be on the current year needles, much more so than on the second year needles. There was frost damage, but it had not occurred during that time. There had been a frost about a month earlier, and it was quite evident on some of the plantations, which I reported on my trip report, especially on Steyer No. 2 plantation and Custer's Home plantation. This is quite different. It's a total necrosis of the young, developing branches in this particular case, because the frost occurred during early candle stage of the spruce, or the early growth, I should say, of the Douglas fir and the spruce in the area. That's about all I can think of right offhand.

Q What type of maple species did you examine?

A It's primarily sugar maple.

Q Were there other species in the area?

A Of maple?

Q Yes.

A Yes, there was. There was a mountain maple there. I forget which Acer it was. There was a lot of Clematis -- there were a lot of Rhododendrons in the area. There was Blackberry -- I have a list; it's a very long list. I think if you look at Dr. Skelly's trip report, he could give you a list of most of the species that I collected, also.

Q Did you collect any oak species?

A Yes, I did.

Q Were tests conducted on each one of those species?

A For what?

Q For damage, for SO_2 damage.

A They were photographed. Primarily, what I did with the material I brought back from the Mount Storm area, they were primarily photographed. I don't remember how many of those we did for sulfur analysis.

Q What oak species did you find?

A I don't remember which Quercus it was. It might have been Aba, but I'm not sure, I'd have to check I think you'll find it in Dr. Skelly's report there.

Q Other than oak and maple, what other species did you examine and what species did you take tests on?

A I don't remember all of them. I have a series of probably 50 pictures each of these, each with the genus and species that I have in the lab, and I can make those available if you'd like.

Q Was damage observed from sulfur dioxide?

A It was concluded by me, as well as others, that the majority of damage was from sulfur dioxide fumigation.

Q Was this general for the total region?

A During the fumigation period?

Q Yes.

A There was, as I said before, some damage from the earlier frost, a month earlier, but other than that, everyone was, I think, fairly convinced of sulfur dioxide damage.

Q Was there any damage that you could determine from sulfuric acid mist?

A There always had been sulfuric acid damage in the area. This is why the loss or the loosening of the needles from the fascicular sheaths had occurred on the previous year's growth. The base of those needles was inspected; in fact, I brought some back for histological work. Those were necrotic. That was from acid rain, but it was from acid rain for -- let's see -- that was in June, July -- so therefore, you have 14 months' exposure to those needles.

Q What was the percentage of damage from the sulfuric acid mist?

A I did not carry out quantitative studies on percentage.

Q And may I assume, therefore, you didn't have any quantitative data relative to the SO_2 damage, also?

A I only have photographs showing mountainsides completely burned out by the fumigation.

Q Whether that was from wind or SO_2 or a combination?

A It was definitely not from wind.

Q How about ozone?

A Well, we had high ozones there, but I doubt very much if -- if it had been ozone, then you would have had to have said that the ozone came from the power plant directly from the stack, because on one side, south of the stack, there was no damage burnout of the vegetation throughout that area; in fact, that's the first place they took me when I went into the area -- there was very little damage, and I thought I might as well go home, as I say in my trip report; however, downwind from the stack, there was burnout -- in fact, I have pictures with me if you'd like to see the pictures of over four or five miles of solid damage from sulfur dioxide fumigation. If it were ozone, then the ozone came from the stack, Mr. Peterson.

Q What I'm -- what I want to go through, I have read the trip report, and I don't see in the trip report where you mention anything other than sulfur dioxide and sulfuric acid mist as causal damage. You don't mention fungus or oxides of nitrogen or fluorides, do you?

A That is correct. I do not.

Q And may I assume, therefore, there was no damage from those elements?

A No, you cannot assume that.

Q Why were they not included in the trip report as causing damage from what you observed?

A I believe that if you read the trip report carefully, you will see that fumigants, the emissions of coal-fired plants, caused the fumigation. I did talk about sulfur dioxide within those emissions. I think I even did mention the other emissions once or twice. I did not carry that on a primary talked about sulfur dioxide fumigation.

Q Was there damage -- well, I guess there was damage from wind tatter, wasn't there?

A Yes, there was.

Q You have the trip report there. Would you point out to me where you mention damage from fluoride?

A I don't think I mentioned it from fluoride, but I'll go through it. It won't take very long. Well, let me read you the second paragraph on the first summary page. "The foliage necrosis occurring in the southern portion of the Mount Storm area was primarily caused by the Vepco effluents, which were carried by the strong westerly and northwesterly winds of

Hurricane Agnes. There is foliar damage in this southern portion of the area which can be attributed solely to the strong winds of Agnes, but the majority of the damage was, in my opinion, caused by heavy fumigation by phytotoxic gases which probably occurred and lasted for several days.

Q You didn't specify the gases, you just made a generality?

A That is correct, and I do it over and over again, in phytotoxic gases.

Q And what do you include as phytotoxic gases?

A Most things that come from coal-fired power plants.

Q Were you able to determine whether or not there was any damage by reason of trace elements?

A No, but that's not a gas.

Q Right. Were there any measurements at the time as to maximum ground level concentrations at the time that Hurricane Agnes fumigated the area?

A Not that I'm aware of.

Q Do you know the emissions that the Vepco plant -- the SO_2 concentrations that it was spewing out at the time of the fumigation?

A It was probably somewhere between 10 and 20 tons an hour.

Q Did you compute that, and from what source?

A From talking to Phil Zinn and Carl Beard, who were -- Carl Beard is the director of air pollution control agency for the state of West Virginia.

Q What kind of sulfur coal do they burn?

A They burn -- at that time, they were supposed to be burning -- it was after the abatement hearing -- they were supposed to be burning 1.5% sulfur coal.

Q Without any abatement equipment?

A With only electrostatic precipitators.

Q Did you make any calculations based upon the emissions as to the ground level concentrations that may have caused the SO_2 damage in the area?

A No, none whatsoever.

Q Do you know if anyone did?

A No.

Q What are the stack heights at that Vetco plant?

A I believe that they're 375 or 400. I'm not sure. I think it should say in the book. I think I'm fairly close.

Q On page 10 of your statement, Dr. Gordon, you make note of one article, quote, the Biological Effects of Coal-fired Power Plants, unquote, and you state there that that report was edited by Dr. Wilson Clark, a member of the Board of Natural Resources. What was his participation in the preparation of that report?

A None whatsoever. He was the editor for the symposium papers, and it was his job, and he did it very fast and very efficiently, to get that report out, edited and out to the public.

Q Did he participate in any of the conclusions that were drawn in that report?

A None whatsoever.

Q How is it that Dr. Clark was solicited or asked to edit that report?

A I really do not know; I have no idea why; maybe it was because I think he has a lot to do with the Montana Academy of Science.

Q Well, there were more reports edited by him than just that paper?

A Oh, heavens, yes, yes.

Q With regard to the activity you undertook to testify on behalf of the farmers, the agriculturalists in the area, am I correct in stating that you performed in a greenhouse and laboratory experiments in Missoula for the purpose of that testimony?

A No, that is incorrect.

Q Where did you perform those experiments?

A Those experiments were conducted for the Environmental Protection Agency under contract to them, which I mentioned earlier, a $16,000 contract, and my task in that contract was primarily to determine the causal agent of the growth abnormalities to the coniferous species of the Mount Storm area.

Q Is this where you innoculated the species in the lab and at the greenhouse?

A In the greenhouse and in the botany gardens. That's right.

Q Would you explain for the record, briefly, what you did?

A Yes. Basically, during the winter-time, somewhere in December or January, we brought trees, young trees, in there. They were at that time about -- I think they were four to five years old, seedlings of Scotch pine, Ponderosa pine, White pine. We break their dormancy slowly by bringing them in slowly from the freezing weather outside. When the candle stage had commenced to take off, we would let it grow for about an inch, an inch and a half, and then we would commence to put drops of acids solutions, weak solutions, of strong acids, in some cases, and then, some weak acids -- hydrochloric acid is a weak acid, nitric acid is a strong acid, sulfuric acid is a strong acid. We applied it with a dropper. We also applied it with a mist atomizer, and I would do this, or someone else would do it once a morning for a given period of time, and then we would wait for the syndrome to occur if it was going to occur.

Q Did you keep records of each innoculation?

A On each of the trees innoculated, there is a tag, and therefore, that was the treatment that that particular tree would be innoculated at.

Q Were there records kept at that time as to the concentration that was applied?

A Yes.

Q At each specific time?

A There was always the same specific pH for any given tree or set of trees.

Q Would it make any difference as to how much was applied?

A I thought it did at that time. It really does not make any difference.

Q Why not?

A Well, because now we're using a squirt bottle instead of the dropper bottles. The squirt bottle is much faster -- that is the squeeze bottle, than the dropper system, which is an eye dropper and we have not found that it causes any faster damage by using more, because it runs off anyway. The only thing that is important is the amount that gets into the fascicular sheath. That is important. No. 2, the temperature in the greenhouse during the time of innoculation is more important than the amount, and the stage of the candle is more important than the amount.

Q Did you keep temperature records at the time of each innoculation?

A No, we do not keep account of the temperature. We know what the temperature is in the greenhouse in the winter-time as far as day-time and night-time temperature. In the spring, we have no control whatsoever over the day-time temperature in the greenhouse except by opening the vents. In the winter, however, you can keep temperatures evenly distributed throughout the day and the night.

Q Would relative humidity have any contribution to make as to whether or not innoculations could be effected?

A Yes.

Q Did you keep records as to the relative humidity at the time of the innoculation?

A For short periods of time, we have. We have not for long periods of time.

Q For what period of time did you keep the records?

A We put a hydrothermograph out there last year to run what the humidity was in the greenhouse.

Q You didn't, however, keep relative humidity records for the studies that you made in '70 and '71?

A No, the only thing I was primarily interested in and which I have testified to, was the syndrome, the visual syndrome plus the histological pathology that was occurring in the tissue -- the tissue pathology and the disease itself was exactly what I was after, and I testified to that in court.

Q The only thing you were looking for was tissue pathology? Was that the purpose?

A And the disease syndrome itself. The disease syndrome had to be there, too, which was the short-long needle, or the adventitious budding or the kinked needles. We never got to the kinked needles.

Q Would you have to develop a certain number of short needles on each candle before you determined that it was a syndrome?

A That question has been asked several times before, under deposition as well as in the courtroom. I did not spend any time counting the needles or measuring how long they were or how short they were. If the disease syndrome, which is quite evident by the pictures I've put into the exhibit here, for my exhibits here, was present, then the tissue pathology of those needles was carried out.

Q Did you apply, or did you have available to you at the time of the innoculations, any rainwater collected from the Mount Storm area?

A No, I did not. I had rainwater available to me, yes, but I did not use it for innoculation.

Q Was there a reason that you did not apply that rainwater to the trees in the greenhouse?

A Right. There was a reason. They would send us, if I am correct, a 250 cc plastic bottle full of rainwater from a given collection. That would not have been adequate -- any given collection of rainwater would not have been adequate to deal with the innoculations.

Q Was the innoculation applied at a specific period of time?

A Yes, usually they were. There were exceptions in the botany garden, but there were rare exceptions in the greenhouse -- it was usually in the morning in the greenhouse, which it still is today. I'm still innoculating now. The garden ones will vary because of the rain. If it's raining outside, then we will wait until after a rain period, so it can vary during the day. Some days you just forget about it because it rains all day.

Q In your testimony at the trial, I believe in 1971, in one of your reports, do you remember stating that"the needle dwarfism we have observed in numerous areas of the United States is caused by one or more acids. It is improbable and may be impossible for this amount of acid to fall on the primordial needles of the elongating pine candle in the 8 to 15 day period when it is essential for innoculation to take place and needle dwarfism to be initiated."

A Yes, I did say that. Yes, that was very early in the Mount Storm study before I had completed most of the innoculation studies -- in fact, before I had initiated the acid rain studies in the greenhouse or in the botany gardens. Yes, it was very difficult to deal with the short-long needles syndrome, and we hypothesized many things during that year and a half, two years, which most scientists would do as they attempt to evaluate what is happening to something never before observed by pathologists.

Q Have you changed your opinion since you wrote that report, or your position?

A Oh, yes, my final report is just the opposite.

Q What factual data or data did you come upon to change your opinion?

A Primarily, the works of Bernat and those of the Swedish, Oden, those works of Likens, Cowling's work in North Carolina, and so on.

Q Weren't those reports available at the time you wrote your report in 1971?

A No. Oden's came out in '72, I believe. I could check.

Q Basically, what did they state that made you change your opinion?

A Of the acid rain falling over Northern Europe causing the death of lakes, the leaching of nutrients, the effects upon materials, and also, the fact that there was acid rain and rather serious acid rains for those areas of the world.

Q Is there sulfuric acid in all rain?

A I would say there probably is some, but probably not in all cases could it be measured.

Q Does the concentration of the sulfuric acid make a difference as to its effect upon the vegetation?

A It definitely does for many species, most species of vegetation. I don't think it has that much to do with coniferous vegetation, however.

Q Why doesn't it have as much to do with the coniferous species as opposed to other species?

A Because of the fact of the fascicular sheath itself. The fascicular sheath, as I talk about in my statement here, my testimony to the DNRC is that the fasciular sheath holds it like a vase, that water, and it will evaporate as it is heated up. This, in turn, increases the acidity of that acid, and as it becomes more and more concentrated, it becomes more and more acid.

Q Is it ever neutralized by dust or by particulate particles?

A It can be, yes.

Q Could that happen in the real world?

A Yes, it could.

Q Did you ever try to duplicate that neutralization effect in any of your laboratory work?

A Yes, we have.

Q And have you found that it did, in fact, neutralize it?

A Yes, we have, with fly ash.

Q What was the source of the fly ash?

A I can't remember whether it was Billings fly ash or it was Mount Storm. I believe it was Mount Storm fly ash.

Q If this effect does happen in the real world, how would you expect to get damage, then, to the fascicular sheath?

A Because of the fact that you have the acids forming a great distance further from where the fly ash falls out. You're dealing here, you know, with 50 to a hundred miles from the sulfur dioxide and nitrogen oxide sources. There's very little evidence that shows that there's much fly ash except for the very fine, at these far distances.

Q Then we wouldn't expect to find any damage from acid rain unless we were 50 to one hundred miles from the plant?

A No, no. You'll find -- the Stoney plantation is 1½ miles from the Virginia Electric Power Company plant. This receives severe acid rain damage, short-long needle syndrome, during the entire period that I was there in the Mount Storm area, and I have received vegetation a month ago which shows that it also occurred during 1975.

Q What is the significance, then, of the testimony that you gave about the fact that you need 50 to 100 miles to neutralize it?

A No, no, I didn't say that.

Q What did you say, then?

A I said that if it does play -- and it could very well -- in the only supporting data that I have, it can play a neutralizing effect, is on a farmer's plantation by the name of Cosner, who was also about a half a mile, three-quarters of a mile, from the Vepco plant. His vegetation, his Scotch pine, all the time I was there, never manifested the short-long needle syndrome. It was heavily loaded, however, with fly ash throughout that plantation.

Q How far was that from the plant?

A Three-quarters of a mile.

Q Besides the fly ash, I believe you testified that dust or soil particles could also have a neutralizing effect?

A I don't believe I said that, but I --

Q Is that true?

A I think in certain cases, yes, that could be true.

Q Could it happen at Colstrip?

A I think if there were a lot of dust in Colstrip, that that might happen, but we find that there is little evidence that there is much dust on the fascicular sheaths in the vegetation around Colstrip.

Q Have you attempted to run any studies or do any laboratory work with regard to the soils or the dust particles at Colstrip?

A As you know, I have carried out histological studies of the vegetation from many of the Colstrip sites, as well as the Billings sites and so on. I find, except in the very immediate vicinity at Colstrip, I find very little particulate matter between the needles and in the fascicular sheath.

Q What about in other areas? What is shown outside of the -- what do your histological studies show outside of the sheath?

A Outside of the sheath?

Q Yes, on the leaf.

A When you process these tissues through the killing solution and the dehydration solution, when I'm doing tip necrosis, which would be just the needles themselves, you find very little particulate matter on those needles. Now, that doesn't mean it will necessarily wash all of the particulate off. If there is a heavy incidence of particulate in the area, they do remain on those needles. A good example of that is a study I did for the farmers around Hall, Montana, on the Cominco Phosphate plant, where the dust particles on that vegetation were as deep as ten micra thick on the vegetation.

Q Have you done any studies which developed whether soil particles were trapped between the leaf and the sheath to determine whether or not it neutralized it?

A I have had -- no, I have not done that.

Q Have you seen any studies or done any studies which showed that condition?

A I'm sorry. I'll have to go through it once more to make sure I understand the question wholly.

Q Well, I believe the question is whether or not you've developed any data which shows dust particles in between the leaf and the fascicular sheath?

A Yes, there are.

Q Did you compare with different areas?

A I have done whole needles from the bottom to the very top, histologically.

Q Just between the sheath?

A No, the sheath only covers about a centimeter. It depends upon the species, of course. On a Scotch pine, you have, I would say, 4/6ths of a centimeter as the sheath covers the sheath -- I mean, that is the sheath.

Q Have you attempted to quantify how much soil material is between the sheath and the leaf?

A No, we are just doing that now.

Q Do you think that might have an effect on acid rain?

A Yes, that's exactly why we're doing this work, and we are attempting now to take the fascicular sheath and the tissues beneath the fascicular sheath and determine the speciations of the compounds in this tissue.

Q When did you begin this work?

A This work was begun -- well, actually, it was the beginning of when we started to take, you know, the tip, middle, the base and the sheath itself, and did separate chemical analyses. That started a year or so ago and when I found some individual who said he could determine what the speciations of those compounds were, possibly.

Q Who is that?

A I would like to know if I have to answer that question.

Q Is it a privileged matter somewhere?

A Yes.

Q Have you got any data on what he's done?

A No, he has not completed the work yet. That's why I'd like to have it back before you know who it is.

Q What kind of methodology does he use?

A Electron-microscopy.

Q Are the studies being done solely in the lab or a greenhouse?

A They are being done from the Billings site and from the Mount Storm site.

Q When is it anticipated that this study will be completed?

A Probably within a month.

Q Are you trying to determine in this study the amount of particulate material or dust material that you find, or just the type?

A The amount and the species, both.

Q And then determine what effects it might have from the amount and the species?

A Once we know the species, we will know the solubility.

Q Has anyone else ever performed that type of a study that you've run across?

A Absolutely nobody.

Q With regard to the Paducah incident that you describe in your trip report, as I understand it, that Shawnee power plant is operated by TVA and has a capacity of about 1750 megawatts?

A That is correct.

Q Is it true that there's a second power plant located nearby, the Joppa power plant?

A That is correct, a 1,000 megawatter. It's across the river.

Q What are the sulfur dioxide emissions from the Shawnee plant per day, do you know?

A Yes, it's in one of my exhibits, which would be biological effects of coal-fired power plants. It's on page -- first, I should tell you it's Exhibit 224-C, and the Shawnee power plant is on page 522 and the SO_2 -- in 1973 -- emitted 228,600 tons of sulfur dioxide, and we estimated that they emitted somewhere around 102,000 of nitrogen oxides.

Q NO_x?

A Yes.

Q How about fluorides?

A These are our calculations now -- 99 tons of fluorides.

Q Annually?

A Annually, and I should say that the sulfur dioxide is TVA's data, not ours. The nitrogen oxides are ours and so are the fluorides, our calculations.

Q When you were in the area, what pollutant damage did you personally observe?

A I drove through the area, of both, I suppose, the damage caused by the Shawnee power plant and the damage caused by the Joppa power plant. The primary species we were looking at were soybeans and tobacco and garden vegetables.

Q Do I read your report correctly that the Shawnee plant was burning 2.7 to 3.3 percent sulfur coal without abatement equipment?

A I don't know where you read that in my report, but it could very well be.

Q I got it from one of the reports, but I don't remember -- I put a note on it here. It may be from Dr. Heck's report.

A It was probably Heck's.

Q There was no pollution control equipment in effect on those plants as far as gaseous removal?

A Right.

Q They just had an electrostatic precipitator?

A Right.

Q They didn't work too well, either, did they?

A No.

Q What species of plants did you find that were affected by the gases?

A Pasture grasses were affected -- I should call it pasture forage, because there was a clover in that mixed in with the grasses. The Cucurbita species, squash, cucumbers and so on, were heavily hit. The potatoes were hit, tomatoes, as far as garden vegetables were concerned. The tobacco was severely hit in the area, as well as the soybeans.

Q Are any of those species indigenous to Colstrip?

A I would say that the only species that were indigenous to Colstrip would be some of the clovers and the garden vegetables, which I think are grown throughout the United States.

Q What clover type, Doctor?

A I believe it's in Heck's report, and I think it's white clover.

Q Is that sensitive to SO_2?

A I think in the atlas, it comes out intermediate.

Q It's true, is it not, that the most important crops in that area around the power plants, agriculturally, are soybeans and tobacco?

A That is correct.

Q And from what we've heard from Dr. Hammer today, we should probably kill all the tobacco, anyway, shouldn't we?

A That is correct, and they're doing a very good job around the Shawnee power plant.

MR. PETERSON: May the record show that Dr. Gordon is just putting out his contribution to that kill.

MR. SHENKER: Mr. Bellingham and I dissent.

HEARINGS EXAMINER: Is he using that form of tobacco that creates the minimal adverse environmental impact?

Q What's the average humidity at Paducah, Kentucky, while you were there?

A Very high.

Q About 80, 90 percent?

A Yes.

Q Do you know its average temperature?

A When I was there, it was extremely warm, in the 90's.

Q Would you say that the environmental conditions that you personally came in contact with in Kentucky when you were there in mid-July are similar to what will be experienced -- to what you have experienced at Colstrip in the same period of time?

A As far as its humidity, never; as far as temperature, possibly, unless it's raining in Colstrip.

Q What is the topography of the Paducah area?

A Flat.

Q How tall are those Shawnee power plant stacks, do you remember?

A Very short. They were approximately 150 to 200 feet, I believe.

Q Is that a fairly old plant?

A It is fairly old. I believe it's early 1960's.

Q Do you consider that the environmental conditions which you personally found at Paducah are similar to what we'll find at Colstrip?

A The environmental conditions?

Q Yes.

A Or the pollution conditions?

Q The environmental conditions, the weather and --

A No, they are not the same.

Q With regard to the Billings area that you described in your report, in your testimony, you cite a study there by James Glenn, Director of the Yellowstone Air Pollution Agency?

A That is correct.

Q Is this the same report?

A No, it isn't.

Q Is there a different report other than December 1974?

A I think I have all of the data for Billings for the last three or four years, the raw data.

Q You may have that, Dr. Gordon, and I don't doubt that, but in your statement, you say: "In Billings and Laurel, James Glenn, Director of the Yellowstone Air Pollution Agency, carries out year-around air pollution monitoring at several locations in the vicinity of the large stationary air pollution sources." Is this December 1974 report one of the reports which he performed in accordance with his duties as Director of the Air Pollution Agency?

A It might be. I have not seen that report.

Q You haven't seen this report?

A No. It says '73-'74, by Jim Glenn, right.

Q Have you ever examined that report other than the raw data?

A No, I only have raw data for Billings.

Q You don't know what conclusions Mr. Glenn came to relative to the source of fluoride emissions and damage in the Yellowstone area?

A I have his raw data on fluoride as well as on sulfur and sulfation and acid mists.

Q You have the raw data?

A That is correct.

Q Do you know what conclusions he, himself, came to?

A No.

Q Do you have any data from Glenn on acid mist?

A He runs one test, and I forget which one it is -- it's not -- for sulfation, and I forget which one he runs -- I think he runs one for acid mist, too.

Q What data do you have that the Montana ambient air standards-- you say secondary standard -- for these three phytotoxic gases, SO_2, NO_x and fluorides, were rarely, if ever, exceeded during the growing season from April to November?

A I have all the data up until -- computer printouts all the way up until January of 1976.

Q Was that data, Dr. Gordon, taken by Mr. Glenn and his associates, or by you?

A That's his data.

Q Do you know whether or not Mr. Glenn found that the fluoride standards were being exceeded in the Billings-Laurel area?

A He told me he has found that. I have not seen any data from him on that.

Q Did any of the samples of Ponderosa pine needles that you did histological work on exhibit sulfur dioxide or fluoride injury?

A Yes.

Q What was the percentage of the injury?

A I would have to look at our writeups on that. The extent of the injury from the GB-1 site, or the Snook's property site on Sacrifice Bluff is reflected in what I had shown you before. Well, it only tells the healthy versus the -- of those needles being retained. I'd have to go back to the other worksheets to find out the percentage of tip necrosis, but we do have the tip necrosis down.

Q Did you examine any other species other than Ponderosa pine at Sacrifice Bluff?

A We have done some Pinus flexilis -- white pine.

Q What did you find as far as white pine was concerned with regard to SO_2 injury?

A SO_2 injury -- we've done histological tip burn as well as basal acid burns on the base of these white pines.

Q And found damage?

A Yes.

Q And fluoride?

A Fluoride high concentrations in the white pine.

Q How high?

A I can't remember right offhand. I could look it up if you'd like me to.

Q Maybe you can provide that to me, too.

A I think it's in here.

Q Why don't you look it up?

(PAUSE TO COMPLY.)

A Pinus flexilis 1971 needles, 64.5 parts per million, fluoride. 1972 needles, 46 parts per million, fluoride. 1973 needles, 37.9 parts per million of fluoride, 1974 needles, 14.9 parts per million for fluoride. I have two pages or so of fluoride -- more than that, I have 3 --

Q Is that white pine?

A It's Pinus flexilis -- it's white bark pine.

Q What is the technical name for the white pine?

A Pinus flexilis.

Q Are there any other species that you examined?

A Juniper, yucca, ag spic, stipa, Artemesia Tridentata and Artemesia Cana.

Q Did you find any damage from SO_2 or fluoride on any of those species?

A I did not look for necrosis. We were looking for the concentrations of sulfur and fluorides in those species.

Q Were they within normal ranges?

A I can give you a reading here, if you'd like. The Scopulorum --

Q What exhibit is it?

A I have no exhibit. I can put it into an exhibit if you'd like me to.

Q Go ahead. Just read off a few.

A Juniperus scopulorum, four samples, the mean, 42.5 parts per million.

Q Is this for fluroide?

A Right. The high 119.4 parts per million, the low, 11.8 parts per million. Large sage, Artemesia tridentata, two samples, year of foliage '74, the mean, 13.3, the high 19.3, the low, 7.4.

Q Do you consider those to be within normal ranges?

A No, they are not.

Q Were these all taken from Sacrifice Bluff?

A This is Snooks's property. I also have data for Kampfe's property out on Billings Heights.

Q What did you find out there?

A Ponderosa Pine, 5 samples,'71 needles, the mean 3.9, the high 4.7, low 1.6,'72 needles, 3.6 for an average, 5.1 for a high, 1.5 for low. '73 needles, 3.5 for an average, 4.8 for a high, 1.9 for a low. '74 needles, 2.0 for a mean, 2.9 for a high, 1.4 for an average.

Q Those are within normal limits?

A No, they are not.

Q They're high?

A They are high.

Q What would be normal?

A What you see in the low range, 1.5 to about 2.5.

Q What did you find on sulfur dioxide at the GB-2?

A Sulfur itself? Ponderosa pine, Billings, Snooks's property, 1971 needles, 1700 parts per million.

Q I asked about GB-2, but --

A Oh, you want Kampfe's?

Q Yes.

A I'm sorry about that. This is GB-2, Kampfe's site. Ponderosa pine -- these are single samples, this whole page is single samples -- '71 needles from tree 2026-A, 700 for '71, '72, 700, '73 700, and '74 400. Those are all in parts per million.

Q All 700?

A All 700 except '74, which is 400. I would consider that fairly normal.

Q Why would the older needles there have a higher number?

A In this particular case, I'd have to go back -- well, let's see. It was collected in the fall of '74, so actually, those 700 readings are what you'd call normal. The 400 is below normal.

Q Is there any reason for that in your opinion?

A What, the lower?

Q Yes.

A We find that the latest current year needles fluctuate in this low range sometimes. Why that happens, we don't know. It may be a sulfur deficiency or something like that, or a transfer, a translocation of it.

Q As I understand your testimony, all of the findings on sulfur for '71,'72, '73, are considered to be normal?

A Yes.

Q Now, on fluorides, what readings did you get on GB-2? Excuse me, you gave me those. Did you make an examination for any other damage, any other phytotoxic acids other than sulfur dioxide and fluoride?

A Those were the only two.

Q No ozone?

A I did histological studies in both areas and I did older needles as well as younger needles. If ozone is the cause of the damage, it will occur primarily on the older needles on that tree and not on the younger needles.

Q Did you find any ozone damage?

A I have not done any histological studies which have shown me ozone damage in the Billings area.

Q Did you do any needle retention survey at this area?

A Yes, we did. GB-2?

Q Yes.

A Yes, we did.

Q Do you have that data?

A Yes, I do. GB-2 -- these are the trees out on Billings Heights.

Q The 1974 needles had a needle retention of 95%. Of those 95% being retained, approximately 87 to 88 percent were healthy, without, therefore, flecking, chlorosis, necrocis, or insect damage. 1974 needles, the needle retention was approximately 89%. Of the 89% being retained, 85% of those needles were healthy, without chlorosis and so on. 1973, the needle retention was 55%. Of that 55% being retained, approximately 48%

were healthy. 1972, needle retention, 70%. Of those 70% needles being retained, again, 48% of those were healthy.

Q Do you consider those ranges normal?

A No, I do not.

Q In what respect?

A They are below normal in any of the sites that we have in the Colstrip area.

Q How far off the normal limit are they, for example, for 1975?

A I would be hazarding a guess, you know, at this time, until that material comes out on a computer. I can give you an approximation. I could be off 10%, maybe 15%.

Q You mention in describing the needle retention that anywhere from 48 to 80 percent, dependent upon the year, were healthy and the rest were damaged by necrosis and so forth. Is that from fungus?

A Again, I would have to tell you what I remember from looking at these charts. All of this data is being fed into the computer. I will say this: the Billings sites, both GB-1 and GB-2, had a higher incidence of tip necrosis and basal necrosis than any of our Colstrip sites.

Q From what cause?

A I did not do all, of course, the histology on all of the needles that we collected. Of those that I have done from the Billings area, the damage close in at GB-1 is primarily, predominantly the fluoride fingerprint; farther out, as far as tip necrosis in the Billings area, that's sulfur dioxide damage.

Q While we're on the fingerprint method, Dr. Gordon, there are a few things I'd like to have you explain to me relative to your photographs, if you'd look with me. With regard to 240-A --

A Just a minute, I'll give you a legend for that.

Q Do you have a legend for each one of them?

A Except the last plate.

Q Let me take a look at the legend and maybe we'd save some questions.

A Okay.

(PAUSE.)

Q Dr. Gordon, with regard to the histological studies and the fingerprint method, how many different species have you analyzed for fingerprinting?

A Oh, gosh! Lots.

Q A hundred?

A Oh, heavens, no. I would say it's in the neighborhood of 30 to 50 species.

Q What coniferous species have you analyzed?

A Do you want to go through them?

Q Yes.

A Pinus taeda, Pinus echinata, Pinus paulustris, Pinus sylvestris, Pinus virginiana, Pinus resinosus, Pinus strovus, Pinus banksiana, Pinus monticola, Pinus flexilis, Pinus jefferyi, Pinus ponderosa -- those are the ones I think of. I think those are the major ones.

Q Do you look for a particular characteristic to determine the damage, the cause of the damage, as to the particular gas?

A I look at the tissue pathology that's being manifested within the transition zone of the necrosis. What I mean by that transition zone, it's between that which is totally necrotic, that which is yellow, and that which is green tissue.

Q Where do you look for that?

A In the transition zone between the necrosis and the green part of the needle, and I take a 2-millimeter to sometimes a 3-millimeter. If I think it's going to be ozone, I take a longer section, which would be three millimeters versus the two millimeters if I think it's going to be a sulfur dioxide or a fluoride or this type of damage.

Q Do you look at just one part of the needle, the damaged part, the tip, or what?

A May I draw it on the board to show you?

Q Sure.

A Thank you.

(WITNESS MAKES DRAWING ON BOARD.)

A This is the fascicular sheath and the bark where it's attached to the stem, the tip. When necrosis occurs from a phytotoxic gas such as ozone, fluoride, sulfur dioxide, nitrogen oxide, necrosis occurs and this is because of the fact that these chemicals, once they get inside the needle, travel to the tip, and this is where the necrosis occurs, so with each increasing amount of fumigation, be it chronic or acute fumigation, you have this continuous necrosis. Between this brown area here and this green area here, there will be another, usually be a very small, light yellow area, and then this (indicating) will be green. My sections are taken from here, using a two millimeter section, and then they will look like -- if this happens to be a 3-needle pine -- this, in the green area -- and they will look like this in the necrotic area -- and then I will go put these through a series of killing solutions, dehydration tertiary alcohol series, and then I will section them and I'll section both longitudinal sections as well as cross-sections, and what I look for is a tissue pathology primarily in the vascular tissue, pathology within the resin canals -- here are the two vascular systems -- and also, we watch the food-producing area here, the mesophyll, some of the tissue pathology in the mesophyll.

Q Now, are you able to determine, or have you been able to determine a particular characteristic, say, for ozone, sulfur dioxide, fluoride?

A Yes.

Q What are those?

A I will show you.

(WITNESS MAKES ANOTHER DRAWING ON BOARD.)

A First, I will go through the longitudinal section. We can go through the cross-section later on. If this is O_3, ozone damage, this is the necrotic end down here, and this is a green here (indicating). If it is ozone damage, the primary damage, the first damage, occurs to the mesophyll tissue, and so you have a V-shaped type of necrosis in this manner, in this way. What I'm saying is that this will be necrotic here and that the mesophyll is destroyed prior to the vascular system being destroyed. That is ozone. We use the ozone, in fact, almost invariably, it occurs on the older needles prior to occurring on the younger needles. If we have SO_2, we have this type of damage, where, again, this is a necrotic end, and this is a green end. The vascular tissue is damaged ahead of the mesophyll or the food-producing cells; also, you have a -- well, I'll do fluoride, and then I'll come back and show you the difference between fluoride and sulfur dioxide, because there's no problem identifying the ozone. The ozone is readily identified from all other gases. The only two you have problems with, that most people would have problems with, if they were a beginner or novice, would be the sulfur dioxide and the hydrogen fluoride. HF, which you have here, is necrosis all the way up to the vascular tissue, deep into the vascular tissue, mesophyll tissues, the last to be damaged. Now, what you're looking at here is not only a deeper penetration by the fluorides into the vascular tissue, but a different type of tissue pathology. In pathology, fungal pathology, we talk about those fungi which are kings. They treat their host with tender, loving care and they take a whole year, a full growing season, to kill that host. They're obligate parasites, and so they treat the cells of their host with this type of care so they don't collapse rapidly. That's the type of gas that you have with fluoride. It comes back here, and it, to be sure, damages these cells, but these cells become very enlarged. They undergo what we call hypertrophy, and that's a sort of cancerous-type growth in here, but sulfur dioxide is not quite that nice of a pathogen, and what we call in humoral pathology, we call slobs. They go in and terrorize the host tissue and maybe they don't care if their host survives or not, and when sulfur comes in here, it causes some enlargement of the cells, to be sure, but the cells soon collapse after this, and so you have a great deal more total collapse, necrotic tissues, from the sulfur dioxide than you do from the fluoride. The fluoride treats these cells rather tenderly in the sense that it will cause the hypertrophy before the collapse.

Now, do you want me to do a cross-section? It's very easy to visualize, if you simply take a cross-section through here (indicating). If I were to make some cross-sections, then I would take this piece here, turn it this way, and you would note that I'm seeing necrotic mesophyll here and here and nothing to the vascular tissue. The vascular system is left untouched. That's an ozone. If I took a section here, it would look the same, and here, and here, and here. Now, let's turn it around and take the section for fluoride. You look here and you'd have absolutely normal mesophyll here, but the vascular system would be undergoing this hypertrophy and this pathology, quite different than in the ozone, and also, quite different than sulfur dioxide.

Q Are those characteristics shown on every one of the species that you've listed for us here earlier? Are the characteristics the same?

A When I make sections, we usually will section four needles from a collection, be it a tree, for instance, that will be the tree. Which four those are is a matter of chance, in a sense, because I will select out eight and maybe twelve needles that I have decided are the ones that will best be suited for histological studies, so the four is one of those eight, or one of those ten, or one of those twelve. Two of those needles will be taken in longitudinal sections and two will be done with cross-sections, and there are times that you simply cannot read the material, because it just doesn't give you what you need to understand it thoroughly. Usually, however, with four needles, you invariably will get two or three out of the four which will show you the pathology you need to determine the damage and what caused that damage.

Q Is there any different pathology that you find from natural causes? Frost?

A Frost I can give you very rapidly. If you have frost here -- if this is frost, what you will see, there will be no damage at all to the vascular tissue, in a sense. There will be no hypertrophy. None of those cells underwent hypertrophy. You will have necrosis, to be sure, of those living cells within the vascular tissue, but there will be no hypertrophy; therefore, no cell collapse, no crushing of other cells from the hypertrophy of certain cells.

Q What vascular tissues collapse? Maybe you'd go through that.

A Okay.

(WITNESS MAKES ANOTHER DRAWING ON THE BOARD.)

A Let's take, again a cross-section of a needle. Here is the vascular tissue. Here is -- this area, here, made up of single series of cells, which are called endodermal cells -- in this area here, we have cells that are made up of two different types of cells. One of those cells is a tracheid-type cell, which lacks a nucleus, that is, a dead cell. The other cell there is what we call a -- just a minute, and I'll think of it -- a parenchymatous cell, or parenchyma cell. The parenchyma cells are the ones that are thin-walled, nuclei, and so on, and these are the ones that undergo the hypertrophy or enlargement. The enlargement of those cells, in turn, causes a collapse of the cells, some of the tracheid cells within that transfusion tissue. In Ponderosa pine, for instance, the first enlargement of cells occurs right here (indicating) because this is where the predominance of parenchyma cells is located. When these start to enlarge like that, then they cause the transfusion cells in this area here to become collapsed, just from the pressure itself. In this area right here (indicating), there are special thin-walled parenchymatous cells that are called albuminous cells, and these, also undergo very rapid hypertrophy with chloride and sometimes, also, with sulfur dioxide, but not to the extent that they do with fluoride. These cells in here -- this is the phloem, by the way, and this is the xylem. The xylem are all dead cells, and made up of tracheids. The thick-walled gases don't bother them, usually, but up in here, in the phloem tissue -- and the phloem, by the way, is what takes the nutrients from this area here and transports it to the other parts of the plant, and the xylem is what brings the water up from the roots to the leaf and to the needle here. It's the food-producing area. These cells in here also undergo hypertrophy, both with fluoride and with sulfur. Again, it's the soft -- you might say king-like approach to hypertrophy versus the slob of sulfur dioxide. Sulfur dioxide causes immediate hypertrophy collapse; fluorides cause a soft type of hypertrophy and later collapse.

Q Is there any damage to the meristematic tissue?

A There is no meristematic tissue in a needle once it is grown.

Q Do you have it with any young needles?

A With young needles?

Q Yes.

A Young needles, when the meristem is growing, usually the stomata are not open, and they are fairly resistant to most phytotoxic acids during their early emergence and early morphogenesis.

Q How many years of secondary growth do you get in the growing, mature needle?

A How many years of secondary growth do you get in a fully matured needle? I do not understand the question.

HEARINGS EXAMINER: Why don't we recess until 9:00 o'clock in the morning and start with that question, rephrased, of course.

(HEARING RECESSED AT 5:00 P.M.)